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Comments on the Rabbit Pest in Australia.

The Council has recently given consideration to the question of whether, in the light of numerous efforts made by other bodies in the past, any good purpose would be served by a re-examination of the present position of the Australian rabbit problem. Reports and views of the State bodies administering Vermin and Noxious Weeds Acts are available, and there is, amongst other reports, the extensive memorandum by Mr. D. G. Stead which the New South Wales Department of Agriculture issued some time ago.

There has, however, been an accumulation of practical experience in recent years which is worthy of close study, and the Council determined at its last meeting to seek from certain representative pastoralists authoritative statements of the conclusions to which experience has led them. The views which have been so very kindly provided are of such general interest that, with the consent of their writers, it has been decided to publish them in the article that follows.

It will be noted that the general consensus of opinion of the writers is that wherever possible the best, and, in the end, the most economic, way to control the rabbit pest is to net, to destroy all cover, and then to keep the areas clean by means of dogs.—Ed.

1. From G. S. Colman, Esq.,* General Manager, Australian Estates and Mortgage Company, Limited.

The experience of this company, in dealing with the rabbit pest, is that the most satisfactory method is to net the properties and thereafter reduce the numbers of rabbits inside the netting by digging-out, fumigating, poisoning, hunting, trapping, and, so far as possible, destroying all natural harbours.

Care of netting fences is important, and the netted boundary should be constantly patrolled and repairs immediately effected to any portions damaged by falling timber, storms, &c. Inside netting boundaries, the work must also be continuous, even after numbers have been reduced, and the work of hunting, digging-out, and fumigating has to be regularly conducted to prevent small colonies of rabbits from restarting.

Country where the carrying capacity is so light that the expense of netting would be out of the question presents a problem, although some steps should be taken to prevent it from being eaten out. One method of dealing with the rabbits on large unnetted areas is to mark down the parts thickly infested with rabbits, and then to distribute

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poison by poison carts, moving on quickly to other areas and repeating the process from time to time. Another effective method, which can be used only in the hottest weather, is to net round water at excavations and put in funnelled traps.

In some classes of country, it is even difficult to reduce rabbits inside netting boundaries, and we have had experience in sand hill country where rabbits increased notwithstanding energetic efforts to keep them down. It was ultimately found necessary to divide chains of sand hills into separate netting enclosures, and dig out, fumigate, and hunt in each section separately. This course eventually proved successful.

2. From W. G. Hawkes, Esq., Koonoona Station, South Australia, and a Past President of the Stockowners' Association of South Australia.

Much has been said and written about the rabbit, that apparently harmless little rodent familiar to us in our English school days when we kept them as pets, which, when introduced into Australia, has devastated the land and done more damage than all the other imported fauna and imported flora put together. It is the greatest material curse that has ever come upon us; it transcends all the plagues that were ever sent upon Egypt, and for sixty years or more has baffled all efforts towards complete annihilation. It is accountable, far more than droughts or overstocking (which have been serious enough), for the conversion into desert wastes of vast areas of our inland pastoral lands, an ever-extending area and problem of grave omen and far-reaching consequence. Its ravages in the better class grass and wheat lands of our continent represent enormous annual loss, and still go on.

From its reputed starting point somewhere down in Victoria, the rabbit has invaded the whole of Australia excepting the tropical regions, which appear to beat him. But his wayfarings and transgressions are too well known to need much recording, and the purpose of these comments is to get down to the best means of destruction as far as our experiences have taken us. The climatic and varying values of our Australian lands make it impossible to set down any method of destruction applicable to all, and it is therefore desirable to divide them into three distinct classes:—(i) the wide expanses of purely pastoral country with a rainfall of from 4 to 8 inches, (ii) the lands known as our fringe country with from 9 to 12 inches, and (iii) the inside grass and agricultural and more intense culture lands from 13 inches upward.

(i) *The Dry Areas.*

It is on these lands that a deterioration has taken place, causing grave disquietude to all those who have been intimately associated with their history for the past 50 or 60 years. In its virgin state before the advent of stocking and rabbits, this region was fairly well covered by grass and herbages in good seasons, by bush, low scrub, and trees of greater size. It was a light carrying country, but well suited for successful pastoral operations under proper improvement. To-day, thousands of square miles of it consist of nothing better than a moving waste of sand and desolation. The bush and low scrub have disappeared, and almost every form of edible tree life is dead or fast dying out, for no new growth can live. These Sahara-like conditions, in what may

be termed the dead heart of Australia, are gradually, yet surely, spreading into the better pastoral lands not yet abandoned, and it is this aspect that deepens our anxieties. Over-stocking in some instances, and a pronounced drop in the rainfall for the past twelve years (to what extent induced by the aridity of the country, we do not know) may account in some way for these conditions, but the paramount cause is undoubtedly the rabbit. He has ringbarked every edible bush and tree, and has virtually eliminated every description of ground covering and shelter; as a consequence, the winds have full play, and rains, when they do come, have little beneficial effect.

These digressions serve to open up the question as to whether the rabbit, by his denudations, may not ultimately affect our Australian rainfall, a matter well worthy of scientific observation. As to the means of destruction on these interior lands, it may be taken for granted that over enormous unoccupied areas no system is possible and none is being attempted. The rabbit has it to himself. On the occupied country, something can be, and usually is, done. Unfortunately, for economic reasons, wire-netting cannot successfully be brought into effect. Thousands of miles have been erected, but sand drifts, flood-waters, foxes, emus, and kangaroos, have rendered fences useless, on account of the prohibitive cost of repairs over such huge distances. Likewise, owing to the very light carrying capacity of this class of country, averaging only about one sheep to 20 acres or more, no detailed or intensive system of destruction is economically possible. Some good work has been done by ploughing-in burrows on favoured patches, fumigations, poisoned twigs, and poison carts, but the rabbit ultimately wins, and the money spent is more or less wasted.

The generally accepted position is, therefore, that the rabbit is allowed full play until he reaches a stage of multiplication when it becomes necessary for him to leave his burrows and natural fastnesses and to come down to the waters. This he will not do until heat has driven him to it and until every vestige of sustenance containing moisture has disappeared. It is then that the station manager has his say. At the right moment, all watering places are netted-in, and poisoned water—arsenic, strychnine, or cyanide usually being used—laid in troughs outside the netting. Provided hot weather prevails, and no rain-storms come to enable the rabbit to get back to his haunts, this proceeding usually results in practically a "wipe-out," but, unfortunately, not until the best of the feed has been taken. Furthermore, there is always the odd rabbit that lives through and forms the nucleus of another plague when the drought breaks. It is these survivors that constitute the trouble. From my long experience, I have formed the conclusion that after a wipe-out by the means I have outlined, it takes about five years for a new plague to reach a sufficient intensity to allow a repetition of the wholesale slaughter, this period being, of course, lessened or extended according to the seasons. If we could make a complete clean-up, it might take many years for a new plague to arise, but these odd surviving rabbits preclude that possibility; yet I am strongly of opinion that if these stray rabbits were followed up and located as soon as they commenced to colonize in isolated places, the recurrence of a new plague might be retarded for one or two years. In South Australia at present, droughts and the poisoned

water methods have given us one of these wipe-outs, and we have a splendid opportunity to practise what I have suggested.

In order to appreciate the difficulty of combating rabbits in these vast expanses of dry country, it must be remembered that rabbits will thrive there as well as in the inside country when the seasons are favorable, but as each acre has only about one-twentieth of the producing value of the inside lands, the inevitable economic law comes in and any kind of detailed destruction is commercially impossible.

(ii) *The Fringe Country.*

This is the area over most of our continent situated between the heavy rainfall country and the outer back. It may be taken to carry an average of one sheep to six acres. Upon such country, with the assistance of periodical droughts, rabbits can be reasonably well controlled. Where neighbours are agreeable to share the expenditure, it will stand the cost of wire-netting and repairs. As to the best means of destruction, I would place the ploughing-in of burrows first in order. Next to that, and where ploughing is difficult, I would place fumigation. There are many kinds of fumigating machines most of which are effective; it is for the man who uses them to find out the best. The poison carts I would place last on the list. I have never really liked them, though I have spent much on their employment. They only half do the job, and are responsible for the loss of much bird life and a good many sheep. With care, and discretion as to the right time to use them, they may barely justify the labour and expenditure incurred.

Summed up, by the means I have named, rabbits can be kept under fair control on this class of country, but there must be no slackening of effort. A few good rabbiting dogs on the place form a valuable asset.

(iii) *The Inside Good Lands.*

These take in the good rainfall zones which are able to afford intense and detailed destruction, and upon which, in many cases, there has been, and still is, almost criminal neglect and carelessness. If every owner did his duty, there would be no need for wire-netting, excepting where large tracts of unoccupied or occupied poor class lands adjoin, such as occur in Western Australia particularly. However, taking circumstances as they are, the erection of wire-netting is the first step to be taken. Provided the fences are kept in order, this ensures only having to kill your own rabbits, and it very soon compels your neighbour to fence also if he wishes to avoid ruin. Then comes eradication by the destruction of every form of cover the rabbits possess. This embraces the ploughing-in or digging-out of all burrows, the burning of all hollow logs or brush shelter, and, where rocky outcrops occur, the blocking up of holes as far as possible. Fumigation may be a useful auxiliary in cases where destroyed burrows re-open or give trouble, or where burrows are difficult to destroy. But no system or combination of systems is complete without the aid of dogs. These form a great essential; in fact, without them anything like a good clean-up and the maintenance of such a clean-up is impossible. I have found that the bigger the mongrel the better the dog, provided he has fair pace; but they all want a dash of the greyhound and need control. They must be maintained in good healthy condition and kept on the

chain as soon as their day's work is done, for, if allowed to hang around loose, they will not be so keen to follow their master out to work.

Trapping and shooting are mere palliatives, and can only be admitted on the principle that every rabbit killed is one less, but they take one nowhere towards the goal of anything like the eradication desired and possible.

What it is desired to stress particularly in regard to the conquest of rabbits on good lands, is that spasmodic effort is the most expensive effort of all and more or less a waste of money. Continuous effort must be made with grim determination and vigour until the pest is thoroughly well beaten. Even under such concentration, it will not be possible to get the last rabbit, and constant vigilance will be necessary to prevent the undoing of the work.

(iv) *General Remarks*

I have referred to the gravity with which many of us view the effect of the rabbit over enormous tracts of inland Australia, and the possibility of a Sahara being created with ever-expanding borders. This is undoubtedly going on. Whether such conditions may or may not bring about a lessening rainfall is beyond the prediction of a layman, but the question should occupy the minds of scientists. I see no other means of arrest outside of the discovery of some disease to overcome the plague. It is questionable whether there is any branch of scientific research more important and valuable to Australia than a solution of this rabbit problem. There is nothing possessing such serious menace to the welfare of our country.

My next point is in regard to wire-netting. When many of us fenced in pre-War times, we paid about £18 per mile for 42 x 18 x 1½ inches, or somewhere like that. To-day, the same class of netting runs into £40 or more per mile and forms a heavy burden to those who desire to fence, whether they have the money or not. Every effort should be made to bring this cost down considerably. In dealing with wire-netting in this paper, I omitted to mention that I think it fairly safe economy to use the 1½-in. gauge, though 1¼ is preferable, and I also think 42-in. far better than the 36-in.; the false economy of the latter can be seen on one of my own properties in Western Australia.

Finally, I cannot help again referring to the gross carelessness which prevails in connexion with rabbit destruction almost wherever any one likes to travel in our good parts. I would like to call it by some other name, but, to say the least, it is most unfair to those who are diligent, and is deserving of severe reprobation. Hundreds of thousands of pounds could be saved in the expenditure on wire-netting if every individual would only do his duty.

3. From E. H. B. Lefroy, Esq.,* "Cranmore Park," Walebing, Western Australia.

There is no such thing as a known practicable procedure whereby rabbits in all sorts of varying conditions may be completely eradicated. Nevertheless, it is definitely possible to control the pest within such limits as will prevent loss, provided that the human factors of apathy and resignation to defeat can be overcome.

* Chairman of the Council's Western Australian State Committee.

In the case of Western Australia, it has to be realized that few holdings are completely cleared of timber and scrub. While they are in that condition, it is not possible to adopt effective measures once rabbits have established themselves. In the earlier stages of invasion, the use of poison carts and poisoned water, aided by long and dry summers, did much to postpone increase, but once the rabbits have established themselves in warrens, serious trouble follows. What then is to be done?

In the case of nearly all land-holders, it is a fact that until the pest has a firm hold it is regarded lightly. Increase at first has been so slow that, in almost all cases, the opinion has been formed that there is something about the locality that does not favour the rabbit and that it will never become really troublesome. The fact that the domestic strain of rabbit had been known to exist for very many years along the coast and had never made headway was largely responsible for this erroneous belief. In this State, it has taken fifteen or more years before serious proportions have been reached, and land-holders have refused to accept the advice of those in the eastern States who had been through the mill. The rate at which increase can take place is emphasized when it is realized that the estimated increase from one doe in a Western Australian breeding season under average conditions is approximately 40. This estimate is confirmed by the Chief Inspector of Rabbits in this State. And each year, as the digging-in by the rabbits proceeds, more and more of them escape the attacks of man and manage to tide over the summer and so provide seed for the next breeding season.

Thus the first step must be taken to induce the land-holder and his banker to realize that sooner or later definite steps must be taken to make life intolerable for the rabbit over as large an area of his holding as is practicable. There is no mystery about how this is to be done, but four things at least are essential:—

(1) Rabbit netting.
(2) Destruction of cover and warrens.
(3) Dogs.
(4) Thorough construction and maintenance of fences and gates.

This may savour of mere mockery to most land-holders under existing conditions, with wool and wheat at present prices and with relative costs where they stand to-day. But this statement is made to the community as a whole, and, if our State is to be saved from this scourge, it must be the affair of all sections, not merely one. Costs in this war cannot be loaded upon the land so as to provide improved conditions for sheltered sections. Costs in interest and material will need to be made as low as possible. Wire-netting which cost £20 per mile in 1912 costs approximately £40 per mile now, while wool and wheat are at least no higher than in 1912.

But, given a right attitude towards the problem on the part of the land-holder, his banker, and the governments, the adoption of a proper method of attack will prove the salvation of what otherwise must inevitably be a crippled or ruined industry. The undertaking can be regarded in the same light as a dangerous operation which must be performed to save life. The way is not easy; it is hard. Unfortunately, there is no easy way if a real cure is to be effected.

Wire-netting.

In the case of boundaries joining infested country, 1½-in. mesh netting is not advisable. Many young rabbits up to 8 inches in length pass through this mesh. These young rabbits can, of course, be cleaned up by very careful policing at regular intervals with dogs, provided cover and warrens are destroyed, but this involves time and cost. The writer has used, for boundary fences, a mixed mesh 17 gauge netting which measures 22 inches of 1¼-in. mesh at the bottom and 20 inches of elongated 1½-in. mesh at the top. The saving in cost of this design as against 1¼-in. mesh all the way up is approximately £9 per mile. Except in sand-drift country, this provides a highly efficient fence.

It is, in most cases, a disadvantage to fence a property with rabbit netting unless adequate steps are taken to deal with the warrens and cover. If a whole property cannot be dealt with in reasonable time, it is advisable to do the netting section by section. The size of the sections will depend largely upon the nature of the country and partly on the time the cleaning-up is to take.

In subdividing a property, it is considered sufficient to use netting of specifications 36 x 1½ x 18 gauge. On hard and stony country, it is satisfactory merely to double over the netting for 6 inches on the ground, instead of making a trench, and to place stones along the doubled over portion.

Cover.

By this is meant warrens, scrub, fallen timber, rock holes, culverts, &c. The destruction of warrens is a matter for inquiry for each landholder himself. In sandy country in this State, it is claimed that warrens may be successfully dealt with during summer, while the sand is dry, merely by filling in thoroughly. Many settlers have succeeded by ploughing deep with a dam plough. In the majority of cases, the most effective method of destroying warrens is by means of spade and mattock. It is advisable to have a 4-in. extension welded to the blade of the mattock, and it should be kept in good repair. The aim in dealing with warrens should be not merely to block up and destroy entrances but to destroy the under-structure also. Rabbits have favorite spots on which to burrow, and stragglers will return to an old patch. If the under-structure is intact, the returning rabbit has little trouble in establishing himself fairly safely in some distant corridor underneath, but, if the corridors are all destroyed, the digging has to be done again by the rabbit in order to reach relative safety. Once the warrens and cover are no longer available, the rest is easy by means of dogs and persistence.

Dogs.

These must play an important part in the work of rabbit destruction and control. Some suitable shelter is required, and, for food, the rabbits serve well. Experience shows that the kangaroo dog or the cross can easily be controlled and worked in paddocks where stock are running. Care, of course, is necessary. The mistake of dispensing with all dogs when rabbits appear to be cleaned up and other food has to be provided should be avoided.

Fences and Gates—Their Construction and Maintenance.

Unless the strictest maintenance, following upon sound construction, is rigorously insisted upon, the whole outlay in money, material, and labour becomes useless, in fact, worse than useless. This point cannot be too strongly stressed. The attitude of so many farmers towards fences is that there is no time to maintain them properly, and there is no time to hang gates properly. Any one who has definitely made up his mind that such is the case would be well advised to give up the struggle against rabbits altogether.

Conclusion.

Briefly, then, the plan of attack is this:—

(1) Enclose with rabbit netting the land on which the attack is to be made, enclosing only so much at a time as can effectively be dealt with.

(2) Destroy all warrens and cover on the enclosed area, using dogs during the process.

(3) By means principally of dogs, but at times with guns and traps, clean up the remaining rabbits and those which manage to enter through fences, &c.

(4) Keep fences and gates in proper order by regular inspections. Harvest time for farmers, when there is so much to be done, is very liable to offer a pitfall here. It is probably the most important time of all for fence maintenance, being just at the end of the breeding season.

It will perhaps be said that there is much land on which it would not pay to take these steps. If the land is good and rabbits are there, no one can afford not to take such steps. In Western Australia there are millions of acres worthy of this treatment, and it is on the better land that rabbits make most progress.

In the Avon Valley of Western Australia, there are beautiful rich flats and slopes below thickly timbered and stony hills. The only satisfactory remedy in such conditions will be to isolate the difficult hills by netting them off. In the wheat belt, where there are rich wheat-lands bordered by light lands covered with scrub, it will be impossible to handle the situation successfully while rabbits have access to the scrub land. Here again, unless the scrub can be cleaned up, the good land will have to be isolated.

Since this is an attempt to point the way to a really satisfactory and permanent method of control, little has been said of the poison cart or other methods of poisoning or mere killing. The poison cart is nothing more than a palliative, and it really amounts to a bad habit if persisted in without the adoption of sound and permanent lines of attack. By means of this machine, many millions of rabbits are killed annually, but, in nearly all cases, by the end of each year the number of rabbits is greater than the number the year before. The cart is the best possible means of encouraging vigorous and cunning rabbits by selection. Unquestionably too, other serious troubles have come in the train of the poison cart; in Western Australia, the most serious of these is toxic paralysis.

It is not denied that palliatives are sometimes helpful, and therefore, in our huge unnetted areas, it seems that this infernal machine—the poison cart—must still play a part in the endeavour to keep the enemy at bay, pending the adoption of satisfactory methods. Any method which means just poisoning rabbits without getting rid of cover and warrens is to be compared with a drug for the deadening of pain when a surgical operation is necessary.

As a guiding principle, this oft-repeated dictum should be imprinted upon the minds of all who are concerned with the rabbit plague:—

> "To deal with the rabbit, get him on the top of the ground. If you merely set out to aim at the rabbit himself, you will miss him; but aim at his cover and you will get him."

This article applies only to the agricultural areas of Western Australia. Although rabbits from eastern Australia have been present in portions of the pastoral areas (country with an average annual rainfall of about 9 inches) for about 30 years, progress has been checked effectually by recurring dry seasons, aided, it is believed, by natural bush enemies. In favorable spots, there has occurred considerable increase of rabbits following a succession of good seasons, but each dry year has, in the absence of all surface water and ground feed, meant an almost complete "wipe-out."

The views expressed in this statement do not represent merely the ideas of one individual. They represent the conclusions reached from observation and inquiry over many years in this State and in the eastern States. They are the result of having for many years put into practice faulty palliative methods so commonly used by others but yielding no real relief and offering no permanent cure, and they are the result of having finally adopted, with highly gratifying success over a large area of country, the methods herein recommended.

4. From Sir Frederick McMaster, "Dalkeith," near Cassilis, New South Wales.

To those gentlemen who still persist in advocating the many prehistoric methods and in ignoring the only possible means of total extermination of the rabbit pest, I ask the following questions:—

> If a man wants to grow a garden, does he rely on poison to keep out the rodents? If a man sets out to grow 1,000 acres of wheat, does he run a poison cart or poison water in that area? In every case does he not net and destroy harbour before he can produce a grain of wheat? What applies to the cabbage garden and the wheat field also applies to our natural pastures.

Having exterminated the rabbit on 36,000 acres of difficult country, i.e., hilly black soil, sandstone rocks full of crevices, and two rivers and four creeks running through the entire area, and having kept that area free from the pest for seventeen years, I feel qualified to express my views in the hope that many will follow suit and help to bring Australia, and incidentally themselves, back to prosperity.

First of all, every man must wake up to the fact that either he or the rabbit has to go. It is impossible to make a profit off the best country if it is infested with the pest. During a long and bitter experience, I have tried nearly every practicable means of fighting the

pest, from poisoning to fumigation, digging-out to digging-in, trapping to hunting, dogging to netting, and can say definitely that only one system of attack can ever bring permanent results—first, netting the boundaries; second, clearing out all underground and surface harbour; and finally dogging the area. Any scheme that simply sets out to kill rabbits, no matter how it may reduce their numbers, will never succeed. Nature has an extraordinary way of maintaining a balance among rabbits, as among most other things, and I can say unhesitatingly that the most efficient fumigant ever tried will not get every bunny. Those that escape are always the most vigorous, and, when they find their competitors for feed reduced to a mere handful, they breed up at the most alarming rate.

At a time like the present, when many on the land are approaching, or have reached, the bread line, it seems a mockery to preach the expenditure of money on netting and digging-out. However, let every man do just as much as he can of these two methods and he can be guaranteed a sure but slow return to prosperity.

If a man has 3,000 acres, and nets and destroys the harbour on 1,000 acres of it, that third will give him a living, whereas the whole of it, if allowed to remain infested with the pest, will surely break him.

As regards poisoning, surely we have sufficient experience of this worst of all methods of attack to realize how utterly hopeless it is. At one period, I had eight poison carts going continuously on a netted area of 1,000 acres, but the slaughter of bird life was so tragic that I hate to contemplate it now. For months we persisted, and certainly killed many thousands of rabbits, but we could never get them all, for here again, nature seemed to step in and by her own methods saved sufficient virile stock to enable them to re-infest the whole area in a single season. Truly, it was heart-breaking work. But that was not the worst of it. In addition to poisoning thousands of birds, we had to cope with the problem of collecting and destroying the carcasses of all dead life in the paddock, and long before we could do that the blowflies were so busy that millions of maggots were deposited in those lifeless carcasses, and so a pest at least as menacing to the pastoral industry as the rabbit was assisted to propagate.

How did I succeed in beating bunny ultimately? Only by erecting 134 miles of wire-netting around my boundaries and subdivisions, digging out on a wholesale scale, and policing the entire station with dogs ever since. I have noticed a tendency in recent times to replace digging-out by digging-in. No doubt the former is much more costly than the latter, but, as far as effectiveness is concerned, there is no comparison. Digging-out means total destruction of harbour; digging-in means only closing up all except one of the outlets from the burrows, and either trapping or fumigating through that one opening. In theory this should be effective, but in practice it is not. And if proof of that fact were wanted, I have only to mention that, whilst I need only one man and his dogs to police 33,000 acres of dug-out country, I have to employ three men and dogs to cover 3,000 acres of dug-in land.

There is not a single case of successful rabbit extermination in New South Wales by any other means than netting and destruction of harbour. If the Government has money to spend on the campaign, let the whole grant be invested in netting, and the money will be wisely

spent; but, whatever is done, let me counsel the Government most earnestly not to encourage the poison cart, for Australia would be immeasurably better off to-day if that contraption had never been invented.

I have been told that netting in the far West is impossible on account of sand drifts and other reasons, and though I have not sufficient experience to speak on that class of country, I still maintain that destruction of harbour out there would be infinitely preferable to any method of poisoning. One must remember that when rabbits can be poisoned in millions all natural feed has long disappeared, and when rain comes rubbish mostly grows.

After all it is only failure that is dear, and honorable success, even if one gives one's life for it, is cheap.

5. From C. Wade, Esq., Panaramittee Station, South Australia.

The methods used for rabbit destruction must, of course, vary with the district in which they are to be used. If the country is worth £5 per acre or more, one can go to a much greater expense as a commercial proposition than one can if the country is worth only 5s. or less per acre. In the more valuable country, I think that netting and destruction of cover are essential. Probably fumigation and digging-in the warrens would be cheaper than digging-out, but this is a matter for individual owners and conditions.

There can be no doubt that it would be a commercial proposition to reduce considerably the number of rabbits that are at present to be found on the better class country. Of course, one will never get the last rabbit, as holes get washed or torn in the netting and fresh animals get in, but once the country is cleaned up the expense of keeping it almost clear is not high.

There is more difficulty in dealing with low rainfall country, as the amount per acre that can be spent on it as a commercial proposition is smaller, though the number of rabbits and warrens to be destroyed may be as large or larger. Roughly speaking, the low rainfall country can be divided into that under 6½ inches per year and the 7-in. to 10-in. class. The lower class practically always gets dry enough each summer to enable the owner to keep the rabbits down to reasonably small numbers by netting the waters and using poisoned water, and also using a few poisoned twigs along the watercourses. It is doubtful if the value of this class of country warrants much more expense than is involved in this procedure.

The 7-in. to 10-in. country is a more difficult problem, as, though a certain number of rabbits can be got with poisoned water, it is only in very dry years that any real clearance can be effected. In this class of country, it is not possible to do much without netting, as there is always one man in each district who will not keep his vermin down. Thus there will always be a centre of infestation in each district; all one can do is to destroy as much cover as one can. I think it pays to plough or dig-in the warrens within two miles of water, and also along the banks of watercourses, though few owners could afford to do this straight off: still a lot can be done in slack times by station teams, with

a bit of contract work when one has any spare cash. The constant carrying, and using, of spades in all vehicles will result in the destruction of a large number of warrens each year in the outlying country.

I dislike phosphorized pollard, as it destroys a lot of small birds and so increases our insect pests; still, at the rate the fox is cleaning up the birds, it looks as though this drawback may soon be disregarded. I have seen places kept very free from rabbits by the constant use of poison carts and careful attention to the netted fences. Once the number of rabbits is small, it does not take a large amount of money to keep them down if one never stops keeping them down. The trouble is that people get them low and then ease off for a year, and so they get a fresh start again.

There would be a different set of problems in country with river frontages and low rainfall, but I have no personal experience in this class of country.

While the damage done by rabbits in the low rainfall country is great, it must not be forgotten that much of the damage done by overstocking is blamed on the rabbit. In the early days, people lived on their capital without realizing it, as in dry times stock lived on edible shrubs and low trees; these are very slow-growing things, and the number of stock carried per square mile would have prevented their regeneration without the rabbit. Present-day stocking is as high in proportion, since we have not got the accumulated growth of shrubs, &c., that our grandparents had. Hence figures based on what the country carried before and after the arrival of the rabbit are misleading.

I do not want the previous paragraph read as saying that rabbits do not amount to much; they do, but we pastoralists must take the blame for our own misdeeds.

I do not think that rabbits will ever be wiped out in Australia, but they can be reduced to a point where a reasonably small expenditure will keep them from increasing above that point.

A Note on New Dressings for Fly-Struck Sheep.

By M. R. Freney, B.Sc., I. M. Mackerras, M.B., Ch.M., B.Sc.,† and M. J. Mackerras, M.Sc., M.B.‡*

1. Introduction.

In the course of experiments on the chemical treatment of standard minced liver baits, it was found that amongst the substances which rendered the baits almost completely unattractive to flies were boric acid and glycerine. It was known that these could be combined to form various acids and esters. It was also known that boric acid, though difficult to apply effectively, was highly regarded by some pastoralists as a dressing for strikes and that *glycerinum acidi borici* was a pharmacopoeal preparation for the treatment of inflamed skin and mucous surfaces. Consequently, it was decided to test the efficacy of these acids and esters as dressings for the treatment of blowfly strike.

2. Preparation and Characters of the Dressings.

The preparations with which most work has been done are made in the following manner:—

Glyceroboric acid.—61.8 gm. of boric acid are dissolved in 280 gm. of warm glycerine. The resulting clear solution contains 3.16 per cent. of boron, or, calculated as boric acid, approximately 18 per cent.

Mono-boric preparation.—One mole (61.8 gm.) of boric acid is dissolved gradually in one mole (92.1 gm.) of hot glycerine. The mixture is stirred and heated to 150° C. when 228 gm. of cold glycerine are added. The resulting clear solution contains 3.16 per cent. of boron, or, calculated as boric acid, approximately 18 per cent.

Di-boric preparation.—Two moles (123.6 gm.) of boric acid are dissolved gradually in one mole of hot glycerine. The mixture is stirred and heated to 150° C. when 320 gm. of cold glycerine are added; it is then warmed until it becomes quite clear. It contains 4.50 per cent. of boron, or, calculated as boric acid, approximately 26 per cent.

Tri-boric preparation.—Prepared similarly to the di-boric preparation, except that three moles (185.4 gm.) of boric acid are dissolved in one mole of hot glycerine, and 410 gm. of cold glycerine are subsequently added. This preparation contains 5.27 per cent. of boron, or, calculated as boric acid, approximately 30 per cent.

These preparations are acidic glycerine boric acid compounds dissolved in glycerine. They are colourless, odourless, hygroscopic, somewhat viscous fluids, the glyceroboric acid being the least and the

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tri-boric preparation the most viscous. They are soluble in alcohol, and, though miscible with water, they are hydrolysed by it, a copious precipitate of boric acid being formed. This, as will be seen later, is an important property.

These dressings have also been modified by dilution with alcohols, by varying the proportions of the original constituents, by using different methods of preparation, or by using borax instead of boric acid. These modifications are grouped in Table I. as "allied glycerine boric acid preparations." In addition, glyceroboric acid and a di-boric preparation made from crude glycerine are being tested.

3. The Properties of a Dressing.

A satisfactory blowfly dressing for sheep must possess the following properties:—

1. It should be easy to apply, penetrate readily, adhere well to the fleece and skin, and persist.
2. It must be absolutely harmless to the normal skin.
3. It must not be toxic to the sheep, if absorbed through a wounded surface.
4. It must kill the maggots, and must prevent the formation of fresh pockets by maggots wandering away from the dressed area.
5. It must not impede healing, and should have a beneficial effect by protecting the wounded surface and reducing bacterial invasion.
6. It must prevent re-strike, either by rendering the area unattractive to flies or by killing the maggots that may hatch from eggs laid subsequently.
7. It should not reduce the commercial value of the fleece.
8. It should be cheap.

4. Examination of the Dressings.

As few field strikes were available for treatment, the new dressings have been tested chiefly on artificial strikes in the insectary. The strikes are produced by thoroughly wetting a selected area on the sheep, and then applying about 2,500 newly hatched *Lucilia cuprina* or *L. sericata* maggots. After 72 hours the maggots are nearly full grown, and the skin is more or less extensively invaded. In this way, we have in the past three months (mid-March to mid-June), produced 130 primary strikes on 55 ewes. The strikes treated and dressings used are shown in Table I.

The strikes varied from slight to very severe. The average may be represented as a strike covering 15 to 20 square inches, with considerable swelling, moderate to considerable invasion of the skin, with two or three extensions of an average length of 5 inches, at the end of which there are frequently deeper pockets, and with numerous maggots working actively on and under the skin. Compared with normal field strikes, these would be regarded as decidedly severe.

TABLE I.

Dressing.	Artificial Strikes.		Natural Crutch Strikes.	Re-strikes on untreated Strikes.	Pockets remaining from Other Dressings.	Totals.
	Body.	Crutch.				
Glyceroboric acid	16	6	..	..	..	22
Glyceroboric acid (made from crude glycerine) ..	7	..	..	..	..	7
Mono-boric preparation ..	23	2	2	..	..	27
Di-boric preparation ..	14	5	5	1	2	27
Di-boric preparation (made from crude glycerine) ..	1	2	..	2	..	5
Tri-boric preparation ..	20	4	..	..	..	24
Allied glycerine boric acid preparations	12	..	1	..	..	13
Other treatments for comparison	18	..	..	..	..	18
Totals	111	19	8	3	2	143

A few strikes were efficiently prepared for dressing, i.e., the wool was shorn closely, the invaded tissues were freely exposed, and the maggots were removed; but, in order that the tests of the new dressings should be thorough and rigorous, the fleece was usually left about an inch long, and the maggots were disturbed as little as possible. Care was always taken, however, to define every extension and to apply the dressing adequately to every part of the strike and the adjacent skin. In a few cases, the dressing was applied without removing any wool. It is nevertheless to be understood that we consider close shearing essential in station practice.

(i) *Application of the Dressings.*

These dressings do not spread spontaneously, but are easily rubbed in, and then penetrate readily to all parts of the strike, including cracks and folds. They adhere well to the fleece, skin, and wounded surface,

and, because they hydrolyse in the presence of lymph, the struck area is thoroughly impregnated with boric acid. Consistency is satisfactory in warm weather, but in cold weather some of the dressings are thicker and stickier than is desirable.

It is a small but practical point that these dressings are pleasant to use, and prevent the smell of the strike from persisting on one's hands.

(ii) *Effect on Normal Skin.*

A scab or crust in the fleece greatly increases susceptibility to strike. Consequently, any dressing which produces an inflammatory reaction on normal skin is regarded as definitely harmful. To test this point, we shear closely an area 4 inches square, apply the dressing liberally, and rub it in gently. A similar area is treated with water, as a control, because some skins are so tender that mere clipping and rubbing may produce a mild reaction. If the dressing be harmful, swelling and redness will be seen in 24 hours, followed by hardening, and within a few days a definite crust will be formed. *This method is quite simple, and graziers are urged to test for themselves every dressing that they propose to use on their flocks.*

In the present series, 37 of these tests have been made with 17 preparations, viz., saturated watery solution of boric acid, glycerine (pure, semi-refined, crude), the four glyceroboric preparations described above, and nine allied preparations. In addition, the di-boric preparation was massaged seven times into the shorn crutch of one ewe and the shorn back of another. No inflammatory reaction was produced in any of the tests, and those preparations containing glycerine improved the texture and flexibility of the skin. In another experiment, which may for convenience be mentioned here, an area on the side was treated with kerosene. Next day, when the skin was swollen and hard, glyceroboric acid was rubbed into half the area, the other half being left untouched. This treatment did not prevent the formation of a scab, but the scab on the part treated with glyceroboric acid was thinner, cleaner, and more flexible, and it lifted away more quickly, leaving the skin beneath healthier than on the other half of the area.

(iii) *Toxicity to Sheep.*

We have not observed any signs of poisoning in sheep treated with the glyceroboric preparations, nor have we heard of any reported by graziers who have used boric acid dressings.

(iv) *Effect on the Maggots.*

Soon after the dressing is applied to a strike, the maggots become restless and cease to worry the sheep. Many wander down through the fleece and drop to the ground. Those that remain become obviously sick, and die between 6 and 30 hours after treatment. This description applies particularly to treatment with the mono-, di-, and tri-boric preparations, the last being the most actively larvicidal. In none of the 78 strikes treated with these three preparations have the maggots remained healthy long enough to produce further damage to the skin, although pockets of dying maggots may sometimes be found in the fleece.

Glyceroboric acid appears to be less active. In 26 cases treated with this preparation (pure and crude), the results were the same as those described above, but, in four, small numbers of maggots survived long enough to produce pockets in which there was definite irritation of the skin. This is undesirable, because these pockets were formed on areas that were not protected from re-strike by the presence of the dressing.

The allied preparations tested have given satisfactory results.

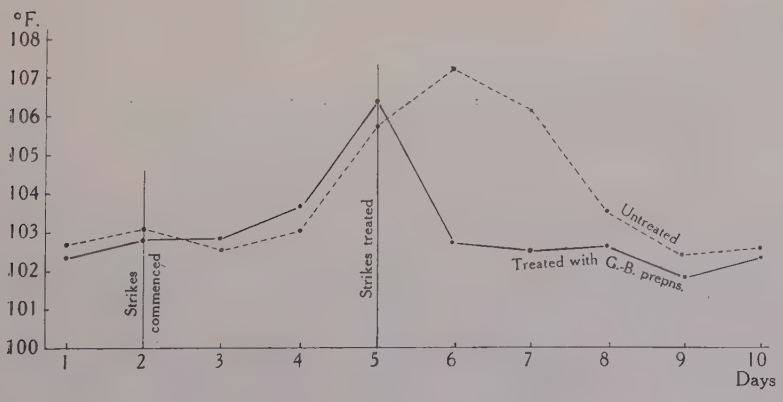
Toxicity tests with some of the preparations gave the following approximate results:—

Feeding tests with young larvae	Lethal concentration 0.5 per cent.
Feeding tests with early third instar larvae ..	Lethal concentration 0.5 per cent.
Full-grown maggots in contact with undiluted dressing for 5 to 60 min.	Average mortality 93 per cent.
Maggots removed from sheep 5 to 20 min. after dressing	Average mortality 73 per cent.
Maggots collected after dropping naturally from dressed sheep	Mortality 100 per cent.

It is noteworthy that glyceroboric acid was as toxic as the other preparations in the *in vitro* tests, so the reason for its relative inefficiency on the sheep is not apparent.

(v) *Effect on the Wounds.*

The immediate effects of these dressings are threefold: the usual, unpleasant, basic odour of the strike is quickly replaced by a much less unpleasant acidic odour; there is a rapid transudation of lymph, which washes the wound from within outward; and the general condition of the sheep rapidly improves. The transudation of lymph is decidedly beneficial to the wound, and involves little danger of later re-strike, for the transudate becomes impregnated with boric acid. The improvement in well-being of the sheep is clearly shown in the records of the rectal temperature, of which the following graph is an example:—



Within 24 to 48 hours, inflamed but unbroken skin returns to normal, and the pitted and ulcerated areas become covered with a firm clean scab. Deep pockets of invasion into the subcutaneous tissue may not be completely covered for another day or two. The scabs remain more flexible and less liable to crack than those formed after other treatments, and they usually lift from the newly-formed skin in 10 to 14 days in moderately severe strikes. Wool growth from the healed area is satisfactory. Suppression of sepsis is not always complete, with the result that there is not infrequently a minor degree of exuberant granulation, and occasionally small abscesses are found.

In their effects on the wounds, the glyceroboric dressings are superior to other substances we have tried. Within the series, the first three preparations are about equally good, and definitely better than the tri-boric preparation, whilst the allied preparations maintain the average.

(vi) *Prevention of Re-strike.*

Using the technique described above, we have made 22 attempts to produce re-strikes on areas that have been treated with the glyceroboric dressings, the intervals between dressing the strike and attempting a re-strike ranging from 4 to 40 days. None was successful, although other re-strikes and strikes on crusted areas were easily produced under similar conditions during the same period. In addition, as mentioned above, a shorn area was treated with kerosene and next day half of it was dressed with glyceroboric acid. It proved easy three weeks later to produce a strike under the scab on the half treated with kerosene alone, but an equal number of maggots failed to develop under the scab on the dressed half.

In vitro, maggots have been reared successfully on scabs resulting from the application of irritants, and from an untreated strike, but none developed on scabs taken from strikes which had been treated with the glyceroboric preparations 16 to 32 days previously. Boric acid has been detected chemically in many of these scabs. In other experiments, the attraction of liver baits to flies was greatly reduced by treatment with these preparations.

So far as our observations go, all the glyceroboric preparations appear to be equally effective in preventing re-strike. These results are encouraging, but field tests are essential before a definite conclusion can be reached.

(vii) *Effect on the Fleece.*

The glyceroboric preparations neither discolour, nor adversely affect, the value of the fleece.

(viii) *Cost.*

Using pure chemicals purchased in cwt. lots, the cost of glyceroboric acid is about 11s. per gallon, and the di-boric preparation about 12s. per gallon. If crude glycerine proves suitable for the preparation of the compounds, the cost will be halved, and, if dilution be satisfactory, it may be reduced to about 4s. per gallon.

The cost per sheep will vary with the size of the strike, and also with the efficiency of shearing, for we have found that $2\frac{1}{2}$ times as much

dressing is required when the wool is left three-quarters of an inch long as is sufficient when it is closely shorn. With the methods of preparing the strikes described above, we used on a average 135 gm. for a body strike and 79 gm. for a crutch strike, the cost being about 3d. per sheep over the whole series. With average field strikes properly treated, the cost per sheep would be about 1d., using pure chemicals.

5. Comparison with Other Treatments.

For purposes of comparison, the main results obtained with the glyceroboric dressings may be summarized as follows:—

(*a*) Penetration and persistence are good, but consistency could be improved.

(*b*) The dressings have no deleterious effect on the skin.

(*c*) The larvicidal action of the mono-, di-, and tri-boric preparations is slow but satisfactory.

(*d*) Healing is rapid and clean, but the tri-boric preparation is less beneficial than the others.

(*e*) All the preparations have prevented the development of artificial re-strikes up to 40 days after treatment.

Four other methods of treatment were used as controls in this series of experiments, the strikes treated and their preparation being similar to those described in the foregoing. These other methods are discussed below:—

1. *No dressing applied, but strikes shorn and most maggots removed.*—Remaining maggots continued to work. Wounds healed slowly under a thick, hard scab; inflamed but unbroken skin also developed a scab. Re-strikes readily produced.

2. *Dressing X.*—Consistency and penetration good, but dressing did not persist. Highly irritant to skin. Killed maggots rapidly. Healing slower and scabs more extensive than in untreated strikes. Maggots easily reared on scabs *in vitro,* but re-strikes not attempted in this series; this dressing is, however, typical of many that favour rather than prevent re-strike.

3. *Dressing Y.*—Solid when cold, but consistency and penetration good at temperatures over 80° F.; persists well. Not irritant to skin. Maggots remained working in strikes up to four days after treatment. Effect on the wounds good, but nullified by the continued activity of the maggots. Partial re-strikes were produced, the skin becoming inflamed, but the maggots died before reaching maturity.

4. *5 per cent. zinc sulphate.*—Consistency and penetration fairly good, persistence poor. Not irritant to skin. Did not always kill the maggots. Wounds healed fairly well, but scab was hard and tended to crack. Re-strikes not attempted in this series, but known to occur in the field.

The glyceroboric dressings clearly compare favorably with these controls.

6. Practical Application.

The real test of the dressings must come from practical station use. We would be glad to have the opinions of any graziers who care to try them out, and the following notes are included for the use of those who wish to do so.

Glyceroboric acid is worth trying, because it is easy to prepare and may give better results in ordinary use than under our rigorous experimental conditions. It is made by adding 3 lb. of powdered boric acid (boracic acid) to 13 lb. (1 gallon) of glycerine. This forms a thick paste, which is heated and stirred until all the boric acid has dissolved. It is then cooled and stored.

The di-boric preparation is probably the best, but is more difficult to prepare. It is made by dissolving gradually 4 lb. of powdered boric acid in 3 lb. of hot glycerine, and heating the mixture to 300° F. 10 lb. of cold glycerine are then added, and the mixture is warmed and stirred until clear. It is then cooled and stored.

Any convenient tin or other receptacle may be used for manufacturing the preparations. They must not be diluted with water, and should be kept in air-tight bottles or tins, because the boric acid tends to separate out on exposure.

7. Conclusion.

The glyceroboric dressings have given decidedly better results under experimental conditions than any other preparations we have examined. Whether they will prove entirely satisfactory in practice remains to be seen. Further investigation is definitely required, and, besides experimental and field studies to test the conclusions already reached, we have four immediate objects in view—

1. Identification of the most desirable compounds.
2. Improvement in consistency.
3. Improvement in antiseptic action.
4. Cheapening production by the use of crude materials, by dilution, and by simplifying methods of preparation.

Sheep-Blowfly Investigations: Observations on the Mules Operation.

*By I. M. Mackerras, M.B., Ch.M., B.Sc.**

This note is supplementary to the earlier paper by Seddon (this *Journal,* 8: 25, 1935), and is based chiefly on observations recently made at "Noondoo," South Queensland, where an extensive trial of the method is being made by the Australian Pastoral Company. It will be followed by a more detailed paper, when the "Noondoo" experiment is more advanced and certain other work now in hand is completed.

Mr. Mules now advocates four distinct procedures, all designed to correct the anatomical disabilities which favour wetting of the crutch with urine, retention of the moisture, and consequent susceptibility to strike. These procedures are —

1. Cutting the tail short, so that it does not press on the vulva.
2. Treatment of erosion of the tip of the vulva.
3. Correction of distorted vulvae.
4. The operation for removing folds of loose skin on either side of the crutch.

The present note is concerned only with the operation for removing crutch folds or wrinkles.

The Mules operation is now performed with "Rol-cut" secateurs, an instrument with a straight blade, which cuts against a brass anvil. Details will be published shortly by Beveridge† but it may be said here that the method is simple, quick, cheap, reasonably efficient, and applicable to flocks of any size and to ewes of any age. Only the wrinkles nearest the vulva, and any adjacent ones definitely subject to urine-scalding, are removed. The writer has performed the operation on lambs, weaners, and old ewes, and has seen about 600, chiefly weaners, treated by others. The sheep showed surprisingly little evidence of pain, bleeding was insignificant, and there was no set-back in general condition, even in young lambs, the immediate effects of the operation being certainly less severe than those following tailing or castration. Within two to three days, most of the wounds were covered with a clean dry scab, and healing, except in rare cases, was complete in fifteen to twenty days. A few cases showed excessive granulation tissue, and occasionally the wounds became mildly septic, but there was never any permanent fixation of the skin to the underlying tissue.

Direct evidence is lacking, but the fresh wounds would probably be as liable to fly-strike as tailing wounds, and the operation should therefore be performed when fly activity is at a minimum. A mildly-antiseptic, protective dressing might be an advantage in assisting healing and preventing strike, but irritant fly dressings would certainly be harmful.

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† These details have now appeared in the *Australian Veterinary Journal* (9): 97, 1935.

The effects of the operation on the conformation of the crutch were excellent, the most dangerous wrinkles for fly attack being usually effectively removed, the crutch opened out, the size of the bare area increased, and urine-staining definitely reduced. In the Australian Pastoral Company's experiment at "Noondoo," 6,844 ewe lambs were treated and 6,845 similar lambs were left untreated for comparison. The following figures show the proportion of plain to wrinkly crutches in these two groups 16-22 days after operation:—

	Plain.	Wrinkly.
Not treated (291 classed) ..	35% ..	65%
Treated group (205 classed) ..	88% ..	12%

In view of these findings, and of the close association between development of wrinkles and susceptibility to strike, one may anticipate that there will be a decidedly lower incidence of crutch strike in the operated group than in the controls.

In his experiment, Seddon found that the strike incidence in the treated group was only one-third to one-half of that in the controls, but he used Burdizzo clamps and removed not only the wrinkles mentioned above but those on the lateral area of the breech and tail as well. Consequently, his results cannot be definitely applied to the operation as it is now performed, although doubt may be expressed whether the more extensive treatment would make much difference to the end result.

It is naturally important, as pointed out by Seddon, that a buyer should not purchase operated sheep in the belief that they are constitutionally of plain conformation. If only the wrinkles that are liable to urine-scalding be removed, no experienced sheepman would be misled, for the treated area is barely visible when the sheep is in wool, and all the other signs of a wrinkly constitution remain as clearly to be seen as in sheep on which the operation has not been made.

The principle of the operation is sound, and the method is both cheap and practicable. While it is most improbable that the operation would render crutching or jetting entirely unnecessary, the information already available indicates that it is definitely valuable, but further work is required to determine its exact value, to eludicate some obscure points, to improve the technique, and to test the other procedures listed at the beginning of this note.

The Peach Moth (*Cydia molesta* Busck). Investigations in the Goulburn Valley, Victoria.

Progress Report for the Season 1934–35.

*By F. J. Gay, B.Sc.**

Towards the end of the year 1934, the Director of the Victorian Department of Agriculture (Mr. H. A. Mullett) was able to arrange with the Canned Fruits Control Board for it to contribute £750, and the Directors of the Commonwealth Bank to contribute £550 (from their Rural Credits Development Fund), towards the cost of an investigation into the Oriental peach moth problem, which was causing some concern to orchardists in parts of the Goulburn Valley. At that stage, Mr. Mullett asked the Council whether it could assist by allocating one of its entomologists to carry out the investigations, on the understanding that the salary and other expenses of such investigator would be met from the contributed funds. The Council was able to accede to this request, and the serivces of Mr. Gay were made available for the work. It was also arranged that the investigations would be carried out with the assistance of an Advisory Committee, consisting of Dr. A. J. Nicholson (Acting-Chief of the Council's Division of Economic Entomology) (Chairman), and Mr. F. M. Read and Mr. S. Fish, of the Horticultural Division and the Biological Branch, respectively, of the Victorian Department of Agriculture. The article that follows is now published on the suggestion of that Committee.—Ed.

1. Introduction.

During the last few years, attack by the peach moth, also known as the Oriental fruit moth, has become particularly acute on canning peaches. The severe infestation during the 1933-34 season, when 40-80 per cent. of the canning crop was destroyed, seriously threatened the survival of the canning industry in the Goulburn Valley. For many years the superficial similarity between the codling moth (*Cydia pomonella L.*) and the peach moth in the larval stage, distracted attention from the damage caused by the peach moth, and from the spread of this moth throughout this peach-growing area.

Prior to the season 1934-35, no connected and specialized study had been made on the peach moth in this district, although K. M. Ward, of the Victorian Department of Agriculture, had from time to time made many useful observations. These formed the basis of much of the present investigation.

The laboratory was established in October, 1934, in a room generously provided by the Ardmona Fruit Products Co-operative Company Limited, which company also made available the facilities of their factory. Opportunities for field work were readily provided throughout the season by the growers of the district, and their aid and observations have been of material benefit to the work.

* An officer of the Division of Economic Entomology, C.S.I.R.

2. Types of Damage.

Damage caused by the peach moth is of two types:—

(1) Newly hatched larvae tunnel the young growing tips, particularly those of young trees, in some cases to a length of 6 inches, causing wilting and death of the affected tips. This causes secondary growth from the laterals below such tips, and in young trees a heavy tip infestation ruins the shape of the tree.

(2) The more serious aspect, however, is the entrance into the fruits, particularly in the chief varieties grown, which are the late canning peaches. The extent of this fruit damage by the peach moth is indicated by the estimated loss of £70,000 to the growers in the Goulburn Valley during the bad season of 1933-34.

3. Life History and Habits.

Previous work by K. M. Ward indicated that there are four broods between September and April in normal seasons, but during the past season a late spell of warm weather resulted in the development of a small fifth brood. Emergence of moths from overwintering cocoons begins about mid-September, and, owing to variable weather at this period, may continue until early November. This protracted emergence of the last brood, however, generally descend from the branches, and broods, so that all stages of the moth are to be found throughout the greater part of the season. For example, adult moths were captured in lures continuously from the end of November to the end of March.

Female moths, which live 13-33 days (average 20 days), lay from 30-150 eggs (average 85 eggs) over a period of 8-22 days (average 15 days). Development to the adult stage occupies approximately 36 days in mid season, and somewhat longer at the beginning and end of the season.

Average figures obtained this season for the various stages of each brood are tabulated below (Table I). All readings are in days.

Table I.

Stage.	First Brood.	Second Brood.	Third Brood.	Fourth Brood.		Fifth Brood.
				Transforming.	Overwintering.	
Pre-oviposition period ..	..	3	3	2		4
Duration of oviposition ..	..	15	17	15		14
Incubation period ..	..	6	6	6	7	6
Larval feeding period ..	..	16	17	13	23	..
Prepupal period	5	5	6	4	..	..
Pupal period	12	11	11	15	..	..
Total cocoon period ..	17	15	15	19	..	..
Egg to adult	..	36	37	37	..	..

Newly-hatched larvae wander freely, testing various sites before tunnelling into the twig and fruit tissue. When testing, the larvae bite out mouthfuls of tissue, and discard them, and this continues during

tunnelling until the larvae are entirely buried, when feeding commences. Newly-hatched codling moth larvae (*C. pomonella* L.) were observed to behave in the same way.

Fully fed larvae of the early and mid-season brood cocoon high up in the trees between adjoining peaches, peaches and leaves, &c. Larvae of the last brood, however, generally descend from the branches, and form cocoons under rough bark and in scars on the trunk, in cracks in the soil, under debris, and in other sheltered situations.

Of this season's broods, 10 per cent. of the third brood, 88 per cent. of the fourth brood, and the whole of the fifth brood are at present overwintering.

4. Methods of Control.

(i) *Spraying.*

The rejection of all surface tissue by the peach moth larvae makes spraying difficult, as there is little chance of stomach poisons being swallowed. Contact poisons used against the eggs and newly hatched larvae appear more promising.

Spraying was restricted to laboratory tests, in an endeavour to find materials suitable for extended field trials next season. Twenty-one materials, both stomach and contact poisons, were tested on approximately 20,000 eggs.

The most promising results were obtained with nicotine sulphate (Black Leaf 40), which gave a 99 per cent. kill. Supporting evidence of the action of this spray has been obtained from several orchards where a light moth infestation was experienced, following the use of nicotine sulphate for the control of green peach aphis in November, 1934. The results obtained definitely merit an extended field trial of this spray next season. Its mode of action has not been determined. It may act (i) as an ovicide, or (ii) as a stomach poison against newly hatched larvae. If (ii) is the method of action, an attempt should be made to combine the nicotine with some other substance in order to retain its toxic properties for a longer period than is at present possible.

Hydrated lime sprays, which have given some appreciable control under American conditions (Stearns and Neiswander, 1929, 1930), gave poor results in laboratory tests and also in orchards, even when four applications were made. Ripening of sprayed fruit was delayed up to seven days.

During the season an experiment in rust and brown rot control on replicated blocks was carried out in the Goulburn Valley by S. Fish, of the Victorian Department of Agriculture. Using dry-mix lime sulphur sprays, actual counts of fruit showed a reduction of moth infestation by 50 per cent. on sprayed blocks. Laboratory observations indicate that this material acts chiefly as a deterrent to oviposition.

Lead arsenate sprays, successfully used against the closely allied codling moth, gave poor control of the peach moth. As the codling moth larva is much larger than the peach moth larva on hatching, these conflicting results may possibly be due to particle size of the arsenate sprays.

(ii) *Bandaging.*

Bandaging of trees during early and mid season is of no practical use, as the cocoons at these times are located high up in the trees. Bandages applied towards the end of February, however, catch many of the descending larvae. Normally, such larvae will furnish the initial infestation of the following season.

At the end of the 1933-34 season, K. M. Ward made a study of the sites of overwintering larvae. The results showed that 63 per cent. of the larvae remain on the trees, the remaining 37 per cent. passing into the soil. The study was continued this season, but confined to the distribution on the trees. Forty trees of the same variety, in four rows of ten, were used. Of these, two rows of ten trees were bandaged in late February, and these bandages were removed three weeks prior to the distribution study. Four hundred and sixty larvae were removed in this way, an average of 23 larvae per bandage. The remaining two rows of ten trees were untreated prior to the study. The results set out in Table II. show that about 90 per cent. of the overwintering larvae on the trees occur on the trunks, under rough bark, in scars, &c.

TABLE II.

Trees.	Total Larvae on Trees.	Total Larvae on Trunks.	Percentage Total Larvae on Trunks.	Percentage Parasitism of Larvae on Trunks.	Remarks.
20 previously bandaged	80	70	87·5	34·3	460 larvae trapped three weeks before study
20 unbandaged	105	95	90·5	12·6	

It will be observed that 70 larvae formed cocoons on the trunks of the previously bandaged trees, from which 460 larvae had already been removed, whereas only 95 larvae formed cocoons on the trunks of the other trees from which no larvae had been removed. This suggests that the number of suitable cocooning sites on normal trees is very small, about four or five per tree in the present instance, and that, except with very light infestations, most of the overwintering larvae descending from the branches must find cocooning sites elsewhere than on the tree trunk. The same inference is to be drawn from work carried out by K. M. Ward in the previous season. Bandages, by providing additional cocooning sites, catch large numbers of larvae which would otherwise migrate from the trees.

Table II. indicates that bandaging has no effect on the percentage of larvae cocooning high up in the trees.

A comparison of untreated bandages and bandages treated with beta-naphthol was made on similar varieties of trees on adjacent blocks. Although experimental conditions were not perfect, the results, given below, are suggestive.

Twenty-six untreated bandages trapped 610 larvae.

Twenty-six bandages treated with beta-naphthol trapped 205 larvae. These results suggest that beta-naphthol bandages are not as attractive as untreated bandages.

The results obtained by two orchardists this season show what may be accomplished by the use of untreated bandages. At one orchard at Merrigum, 2,800 late variety peach trees were bandaged, and random sampling gave an estimated total catch of 22,000 overwintering larvae. At another orchard (at Kyabram) 4,000 Pullar peach trees were bandaged, and random sampling gave an estimated total catch of 42,000 larvae.

(iii) *Bait Trapping.*

Attempts by orchardists to reduce the infestation with large numbers of lures have shown no marked increase in the percentage of clean fruit. There seems little point in using this method until such time as much more attractive lures are discovered.

(iv) *Destruction of Infested Tips.*

The destruction of first brood larvae by cutting and burning infested tips cannot be recommended. Only small trees lend themselves to this work. The majority of obviously wilted tips are deserted, and apparently sound tips frequently harbour newly hatched larvae. On two orchards, one of which is isolated, all visibly damaged tips were removed. More than 6,000 first brood larvae were estimated to have been destroyed by this method over a period of two to three weeks. In neither orchard was the final infestation materially reduced below the general average of neighbouring untreated orchards.

(v) *Cultivation.*

The general district practice is to cultivate deeply, right up to the trunks of the trees, after harvest, and in early spring. According to American studies (Stearns 1927), this should be effective in destroying the majority of overwintering larvae in the soil.

(vi) *Sanitation.*

Orchard props and fruit cases have been found harbouring numbers of overwintering larvae. The use of smooth props without loose bark, and the steam sterilization of cases, offer means of further reducing the carry-over to the next season.

(vii) *Biological Control.*

The peach moth in the Goulburn Valley has several native hymenopterous parasites, which attack the overwintering larvae and pupae. So far, no native parasite of the early broods has been detected. *Dibrachys* sp., the most important of the parasites concerned, is responsible for almost 90 per cent. of all parasitism. This observation, originally made by K. M. Ward, was confirmed this season. This wasp frequents the trunks of the peach trees during autumn and winter months. Untreated bandages cause overwintering host larvae to congregate on the tree trunks, and so favour the propagation of the parasite. Thus, in one set of observations 83 per cent. of larvae in bandages were parasitized, whereas only 12 per cent. of larvae on

unbandaged tree trunks were parasitized. Chemically-treated bandages either kill the hosts before parasitism can occur or destroy the parasites themselves.

Dibrachys does not fly readily, so that concentrations of the parasite, when built up by favorable conditions, do not disperse rapidly. This gives a probable explanation of the fact, shown in Table II., that the percentage of parasitism is approximately three times as high on the trunks of previously bandaged trees as on those of unbandaged trees.

The activity of native parasites in April-May, 1935, showed a considerable increase over the corresponding period of last season (1933-34.) suggesting that a normal host-parasite relationship may be operating here, with the parasites at the present time overhauling their hosts. If this suggestion be true, the expectation for next season (1935-36) would be a lighter moth infestation than during the past season (1934-35).

5. Conclusion.

The work this season has necessarily been of a preliminary nature, but the following suggestive points have been revealed:—

1. Both newly-hatched peach moth larvae and codling moth larvae have the habit of rejecting all surface tissue. The small size of newly-hatched peach moth larvae compared with newly-hatched codling moth larvae suggests that the efficiency of stomach poisons is influenced by particle size.

2. Of the various substances tested as ovicides and cover sprays, nicotine sulphate definitely gave the most promising results. Its compatability with other sprays makes it especially suitable for use in combination with early season routine sprays.

3. The evidence indicates that untreated bandages not only catch large numbers of overwintering peach moth larvae, but also favour the action of native parasites.

4. Native parasites appear to be restricted in their action to the winter months. Arrangements have been made with the United States Department of Agriculture to introduce the Ichneumon parasite, *Macrocentrus ancyclivorus* Rohw., which attacks peach moth larvae in the spring and summer.

6. References.

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A Study of the Inter-relation of Species in Pasture Mixtures Subjected to Differential Treatment in the Canberra (F.C.T.) Area.

*By A. McTaggart, Ph.D.**

1. Introduction.

The importance of pasture improvement to the pastoral industries, Australia's greatest source of wealth, has often been emphasized. Consequently, any studies which can shed additional light on any phase of this important subject are justifiable. One phase of the subject, among others, that seems to warrant attention, is that of making, in definite environments where the artificial establishment of grassland is both desirable and feasible, a systematic study of pasture mixtures, computed on the basis of their assumed suitability.

2. Description of Studies.

To study pasture mixture possibilities, and in general the suitability and inter-relation of individual species comprising the same, for a representative soil type in the Canberra (F.C.T.) area, a block of flat land of silty clay loam type was chosen on the Council's Duntroon Farm, near the Federal Capital. The land, which had been cropped at various times for a number of years, was cultivated thoroughly and put into good general condition for laying down to grass. At the time of seeding, the area received no fertilizer treatment, but two years later (13th September, 1933), it was top-dressed with 2 cwt. of superphosphate per acre. It was subdivided into sixteen contiguous large plots. These plots were seeded on 1st September, 1931, with the mixtures mentioned below. Some thirteen months later, on 5th October, 1932, the various treatments were commenced. These were:—

(A) One-third of each plot was mown closely every six (6) weeks (to simulate frequent grazing).

(B) One-third of each plot was mown closely every eight (8) weeks (to simulate moderately-frequent grazing).

(C) One-third of each plot was pastured closely, periodically, with sheep, when the growth warranted such pasturing.

Just prior to each mowing or pasturing-off, the percentage ground cover occupied by each constituent of each mixture was determined. This furnished a measurement of persistence, and was carried out by use of a modified form of the "point quadrat method of pasture analysis." The precise method employed at Duntroon was to place perpendicularly, at random, 10 times over each sub-plot, the frame with its 10 pins (2 inches apart), noting carefully the species struck by the pin points and the number of times each was struck, and adding up the series of numbers corresponding to each species. These latter totals were taken as the percentages of ground cover occupied by particular species at the time and under the conditions of making the observation.

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The mowing of the series of plots at regular intervals was carried out by use of a motor lawn mower, but, where the seasonal growth was too long to permit of the use of this implement, the ordinary hay mower was used. Where the mown herbage tended to interfere with subsequent growth, it was taken off with a hay rake; otherwise it was permitted to lie where mown. Stocking of the pastured sub-plots with sheep, when the growth periodically warranted such pasturing, was fairly heavy—sufficient to feed off the herbage within a reasonable time.

The following mixtures were studied by this method (the figures represent lb. per acre):—

Mixture No. 1.—New Zealand Hawkes Bay perennial rye-grass (certified "old pasture") 8; New Zealand white clover (earliest "certified"), 2.

Mixture No. 2.—Akaroa cocksfoot, 8; lucerne, 2.

Mixture No. 3.—*Phalaris tuberosa,* 6; subterranean clover, 2.

Mixture No. 4.—Wimmera rye-grass, 6; subterranean clover, 2.

Mixture No. 5.—Tall oat grass, 6; lucerne, 2.

Mixture No. 6.—Tall fescue, 8; New Zealand white clover, 2.

Mixture No. 7.—New Zealand Hawkes Bay (old pasture) perennial rye-grass, 4; Akaroa cocksfoot, 3; tall oat grass, 2; subterranean clover, 2; lucerne, 1; New Zealand white clover, ½; sheep's burnet, 2.

Mixture No. 8.—New Zealand Hawkes Bay (old pasture) perennial rye-grass, 6; Akaroa cocksfoot, 4; *Phalaris tuberosa,* 1; subterranean clover, 1; lucerne, 1; New Zealand white clover, ½.

Mixture No. 9.—*Phalaris tuberosa,* 2; Wimmera rye-grass, 4; tall oat grass 2; subterranean clover, 1; lucerne, 1.

Mixture No. 10.—Akaroa cocksfoot, 3; tall fescue, 4; lucerne, 2; New Zealand white clover, 1.

Mixture No. 11.—New Zealand Hawkes Bay (old pasture) perennial rye-grass, 3; Akaroa cocksfoot, 2; *Phalaris tuberosa,* 2; lucerne, 1½; New Zealand white clover, 1; subterranean clover, 1½.

Mixture No. 12.—New Zealand Hawkes Bay (old pasture) perennial rye-grass, 4; Akaroa cocksfoot, 2; *Phalaris tuberosa,* 2; tall oat grass, 2; tall fescue, 1½ subterranean clover, 1; lucerne, 1; New Zealand white clover, ½; sheep's burnet, 1.

Mixture No. 13.—Wimmera rye-grass, 1; tall oat grass, 4; subterranean clover, 1; lucerne, 2.

Mixture No. 14.—Akaroa cocksfoot, 3; *Phalaris tuberosa,* 1; Wimmera rye-grass, 1; lucerne, 2.

Mixture No. 15.—Akaroa cocksfoot, 4; Wimmera rye-grass, 2; subterranean clover, 2; sheep's burnet, 2.

Mixture No. 16.—New Zealand Hawkes Bay (old pasture) perennial rye-grass, 6; Akaroa cocksfoot, 3; *Phalaris tuberosa,* 1; lucerne, 1; New Zealand white clover, 1.

In further studies of these mixtures which are being made, yield, based upon air-dry weights of forage taken from quadrat cuttings made at the time of mowing or pasturing, is receiving special attention.

The results obtained to date from the studies herein described are dealt with by means of—

(i) the accompanying plotted curves* showing graphically the periodic trend of the average percentage ground cover for each species over all plots in which it was used, under differential treatment and environmental conditions; and

(ii) a general discussion of the data and observations recorded.

3. General Discussion and Conclusions.

An examination of the curves reveals a fluctuation in percentage ground cover, in most species, in a general way correlated with variations in rainfall. This is particularly noticeable when comparison is made with the accompanying histogram showing the rainfall at Black Mountain, Canberra, in six-weekly periods, for the length of time during which the data were obtained. Actually, the rainfall records were taken some 6 miles from Duntroon, but the figures at both stations are sufficiently similar not to affect the results.

The curves for Hawkes Bay (N.Z.) (old pasture) perennial ryegrass (*Lolium perenne*) show a particularly high average percentage ground cover—higher than for any other species—especially under pasturing treatment. While the grass cover fluctuated with the rainfall, the species exhibited marked persistence throughout all conditions of treatment and weather. Its excellence as a pasture grass is also demonstrated in the "pasture treatment" (C) curve, wherein a relative increase in average percentage ground cover is indicated. Sward-forming capacity, persistence, good pasture quality, ready response to increased rainfall, and marked ability to withstand competition were the outstanding characteristics of this grass.

Akaroa (N.Z.) cocksfoot (*Dactylis glomerata*) exhibited a moderately high average percentage ground cover, which on the whole remained relatively stable, particularly under pasturing conditions. Persistence, ability to withstand competition, ready response to increased rainfall, stability, and good pasturing quality are the characteristics of this grass. On the whole, it showed throughout marked value as a permanent pasture species for conditions similar to those represented in the tests.

In the case of lucerne (*M. sativa*), high average percentage ground cover is indicated, with marked stability and a tendency to be but little influenced by fluctuations in rainfall, particularly under pasturing and not too frequent mowing conditions. This was doubtless due to its very deep root system. The legume, moreover, withstood pasturing eminently well, and gave body and balance to all mixtures wherein it was used. Its drought-resisting and excellent pasturing qualities were amply demonstrated, as well as its value as the most stable mixture constituent.

According to the curves, sheep's burnet (*Poterium sanguisorba*) showed moderately high average percentage ground cover. It fluctuated a good deal with rainfall, but showed persistence. It was influenced most by pasturing, owing to the fact that the sheep ate the plants bare to the ground, while on the other hand the mower (under (A) and (B)

*Averages of percentage ground cover for each species associated with each mixture were first calculated. The averages pertaining to these individual species wherever found in any or all of the mixtures were now averaged and the graphs were produced from the latter averages. Space precludes the presentation of the actual data.

treatments) tended to miss the rosette-type plants. Drought-resistance, persistence, responsiveness to increased rainfall, and palatability are the outstanding characteristics of this pasture species.

The foregoing were the four outstanding species of these tests and observations, showing up well under all conditions, which were exacting. A mixture consisting of these persistent constituents is therefore recommended for permanent pasture under the conditions herein described.

Phalaris tuberosa showed fair average percentage ground cover, which was greatest under the less frequent pasturing conditions. While this fluctuated with the rainfall, the grass remained fairly stable throughout. Its greater prominence under the lower competition associated with the simple mixtures, however, tended to raise the average percentage ground cover over all mixtures in which it occurred. Characteristics exhibited by this species were greater suitability for inclusion in simple mixtures of non-aggressive species and greater responsiveness to winter and spring conditions; it is a satisfactory pasture species, for cattle more especially, provided ample time for recovery following grazing is allowed, but it is none too palatable a grass for sheep.

Tall fescue (*Festuca elatior*) also gave fair average percentage ground cover, which did not unduly fluctuate with the rainfall, due, doubtless, to its deep root system. On the whole, it showed a tendency to decline under close pasturing conditions. The grass showed evidence of being persistent (under moderate grazing), very palatable, and more suitable for inclusion in simple mixtures, not too closely grazed, for use in the Canberra type of environment.

Tall oat grass (*Avena elatior*) exhibited a low average percentage ground cover, which fluctuated with the rainfall. It proved to be a very palatable grass which will not withstand much competition. Its tendency to persist and its responsiveness to favorable rainfall, however, increase its suitability for growing in simple mixtures in the more favoured portions of the winter rainfall belt.

Wimmera rye-grass (*Lolium* sp.) was not a success under the conditions associated with the tests. It declined markedly with the onset of prolonged dry weather plus the application of the various treatments. The latter apparently prevented adequate seed formation, which led to the grass being practically exterminated, though it revived somewhat with the onset of higher rainfall, more especially under the less frequent treatment (C) (pasturing). The necessity for proper management of this annual grass, to ensure the essential formation and ripening of seed for natural re-seeding, is seen in these tests.

The curves for subterranean clover (*T. subterraneum*) show this species to be affected markedly by the onset of prolonged dry weather plus the various treatments. Doubtless, the latter failed to permit adequate seed (for self-regeneration) to form. Increased rainfall and the belated top-dressing with superphosphate, however, caused a tendency for the clover to revive somewhat. As in the case of Wimmera rye-grass, the importance of proper management, to ensure seed production and hence self-regeneration in this annual clover, is noticeable in these tests. Early top-dressing with superphosphate seems to be necessary for the promotion of this condition.

White clover (*T. repens*) (N.Z. earliest "certified") was almost a total failure. It was seriously affected by prolonged dry weather, together with the severer forms of treatment. With increased rainfall,

it showed a tendency to revive, particularly under not too frequent mowing conditions. Under pasturing and frequent mowing conditions, however, both white clover and subterranean clover practically disappeared. There is some indication that the use of more suitable strains, together with the employment of judicious grazing, might possibly promote the greater permanency of white clover in the Canberra environment.

4. Palatability and Ground Cover Relationships.

Some reference to certain observed relationships between palatability and average percentage ground cover might be made.

The accompanying plotted curves reveal an increased average percentage ground cover under pasturing treatment (C) for *Phalaris tuberosa*. This increase is believed to be due to the avoidance of the species on the part of sheep, for the latter have been observed to leave the *Phalaris* until all else is eaten off. This observation was confirmed by a similar, but more conspicuous, observation made on the pastured-off portions of adjoining contiguous single grass plots which included this genus. The effect of this avoidance was to encourage the *Phalaris* —hence the increase in its average percentage ground cover. It is conceivable, however, that the vegetative habit of growth of this species is also partly responsible for the increase recorded.

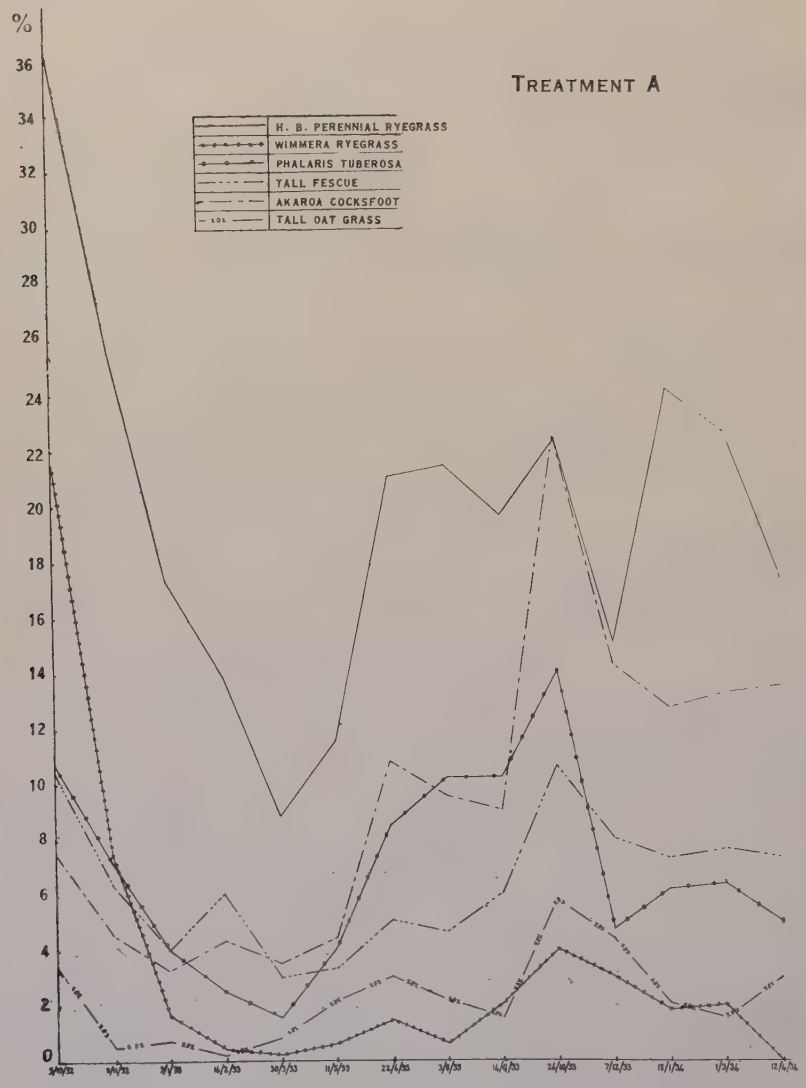
The tall fescue and tall oat grass curves, on the other hand, show a decreased average percentage ground cover under pasturing treatment. This decrease is believed to be due to the greater palatability on the part of these species, sheep having been observed to pasture them very closely in preference to other grass species such as *Phalaris tuberosa*. The effect of such close pasturing has been to retard the growth of these two species in favour of others which are less palatable and which ultimately produced a higher average percentage ground cover. (The fact that *Phalaris* does not withstand competition too well is offset to some extent by its relatively low palatability to sheep.)

The decreased average percentage ground cover associated with sheep's burnet under pasturing treatment is likewise due to its palatability, the sheep tending to pasture its plants very closely as compared with plants of certain other less palatable species. Moreover, under differential mowing conditions, the plants of sheep's burnet (*Poterium sanguisorba*), being of rosette type, in many instances escape the mower knife, and so tend to maintain or increase the average percentage ground cover associated with the species.

The observed increase in the average percentage ground cover associated with the pasturing treatment (C) of Wimmera rye-grass is not the effect of lower palatability, if such be present, but rather the result of the longer interval between grazings, which permitted the formation of a certain amount of seed which in turn was planted under the feet of the sheep to produce new plants.

5. Acknowledgments.

In the procuring of the data and observations dealt with herein, also for the photographic work connected with the graphical representation of the data, I acknowledge the appreciable assistance rendered by Mr. W. Hartley, B.A., Assistant Research Officer (Introduction and Agrostology). To Miss F. E. Allan, M.A., Biometrician, my thanks are also due for the rainfall data.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PHALARIS TUBEROSA
TALL FESCUE
AKAROA COCKSFOOT
TALL OAT GRASS
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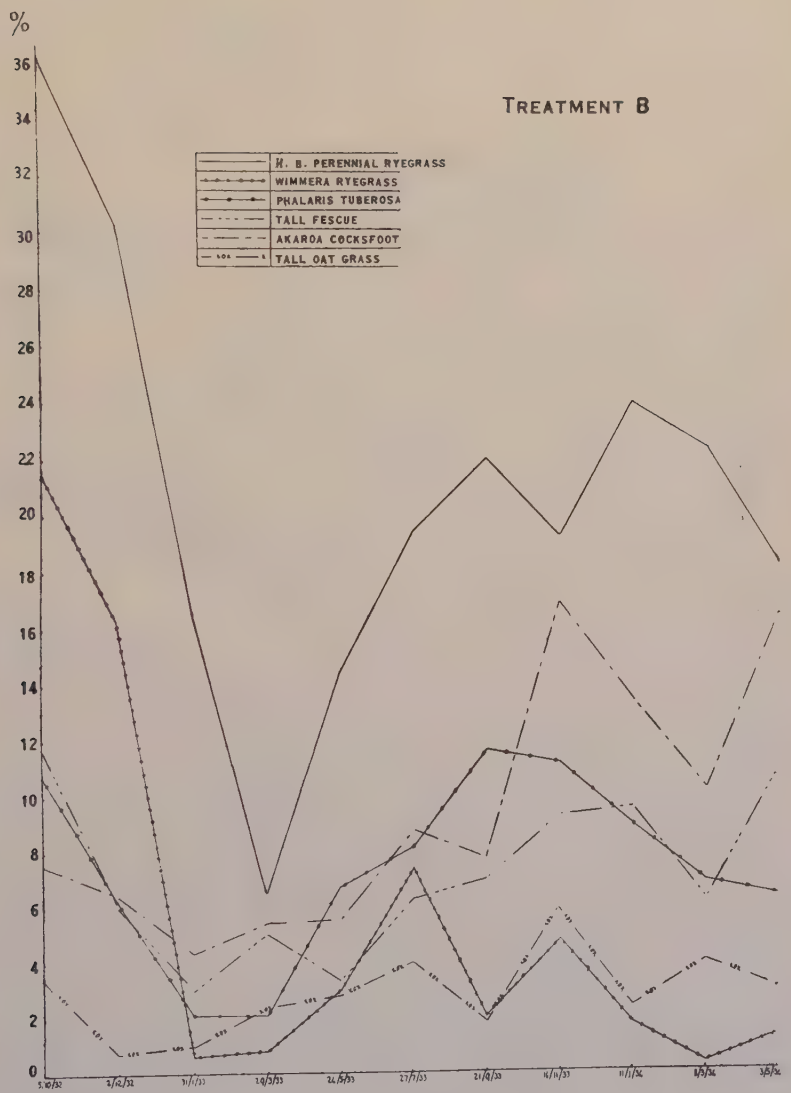
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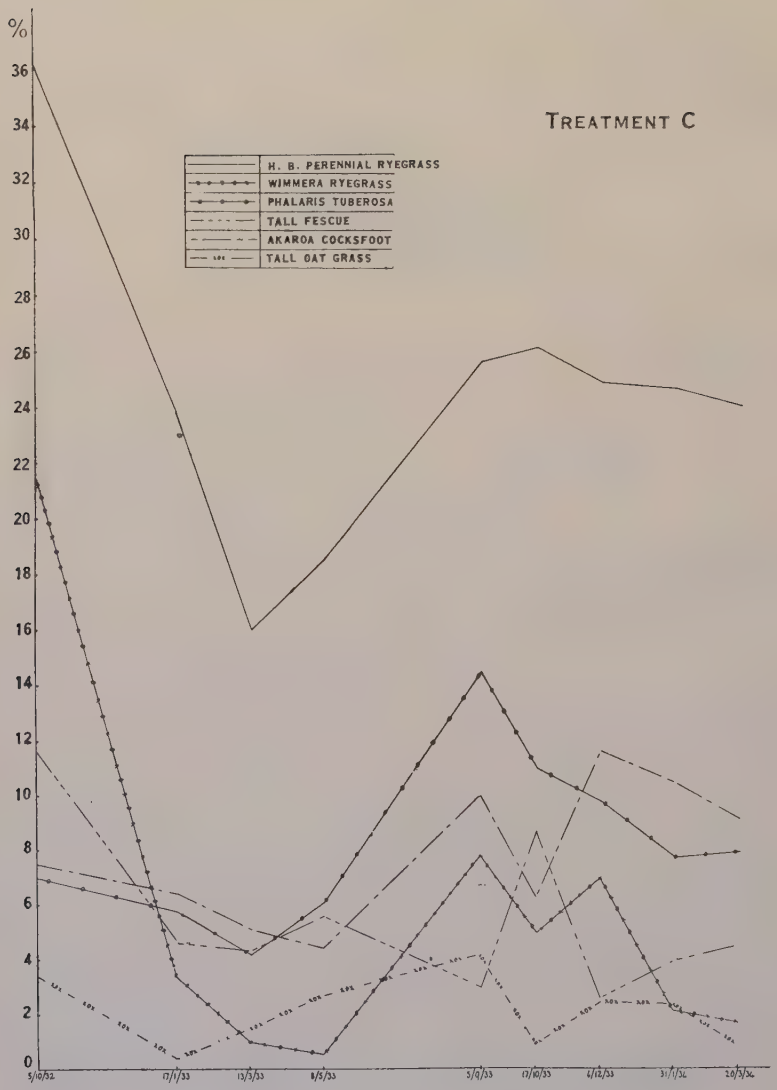
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H. B. PERENNIAL RYEGRASS
WIMMERA RYEGRASS
PHALARIS TUBEROSA
TALL FESCUE
AKAROA COCKSFOOT
TALL OAT GRASS
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20/3/34


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SHEEP'S BURNET
SUBTERRANEAN CLOVER
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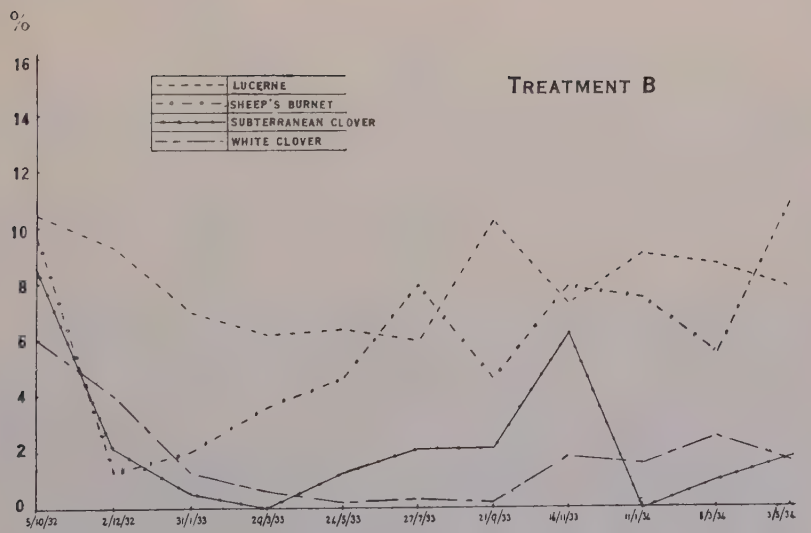
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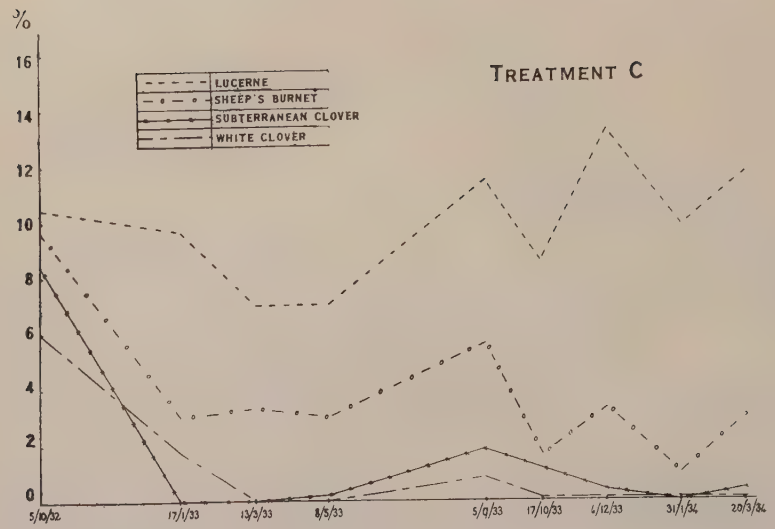
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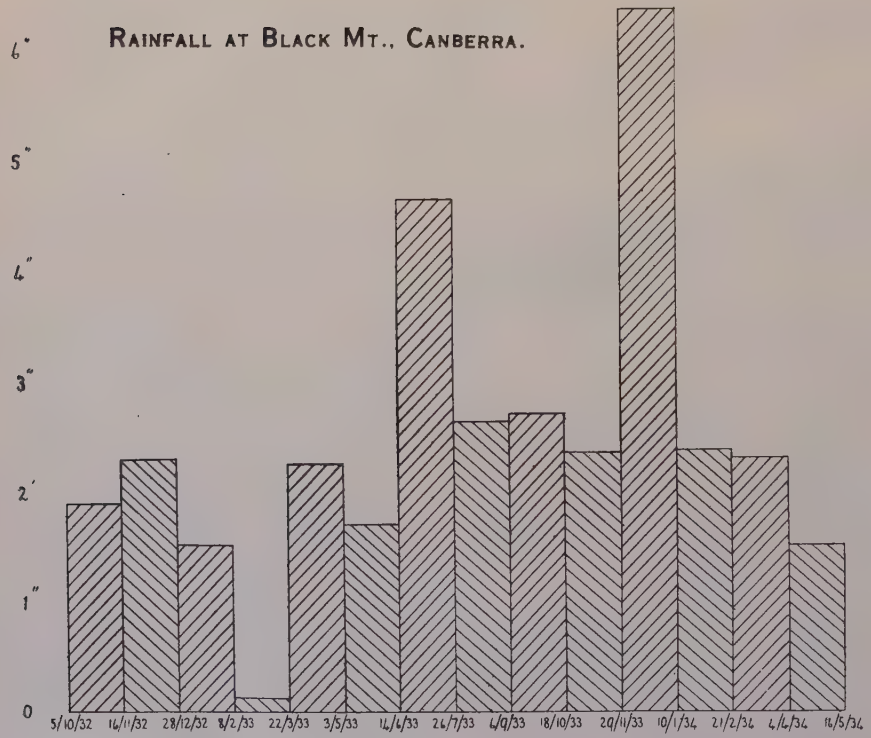
RAINFALL AT BLACK MT., CANBERRA.
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The Chemical Composition of Certain Pasture Species at Flowering and Maturity.

*By R. E. Shapter, A.A.C.I.**

The article that follows discusses work which forms a part of the co-operative programme of investigations in which the Waite Agricultural Research Institute of the University of Adelaide, the Carnegie Trust, and the Council for Scientific and Industrial Research are now co-operating. The Empire Marketing Board also contributed to the scheme for some years (see this *Journal*, Vol. 5, No. 3, August, 1932, p. 141). When the Board was disbanded, and its contributions ceased, the Carnegie Trust contributed a sum of £1,750 for one year and a sum of £900 for a second year towards the cost of the investigations, conditional on an undertaking being given that the work would be continued after the close of the second year. (See this *Journal*, Vol. 7, No. 2, May, 1934, p. 114.)—Ed.

Summary.

Twenty characteristic species of pasture plants, including eleven grasses, four legumes, and five miscellaneous species have been grown under identical cultural conditions in pots, and subjected to chemical analysis.

The results for crude protein, crude fibre, ether extract, nitrogen free extractives, total ash, soluble ash, insoluble ash, and phosphoric acid have been tabulated for the plants harvested at the time of flowering and at maturity.

Where practicable, separation has been made at maturity between the seed and the rest of the plant.

1. Introduction.

During the course of an investigation on the water requirements of pasture plants at the Waite Agricultural Research Institute, opportunities were provided for obtaining plant material, grown under identical conditions, for chemical analysis. In 1931, a group of 20 pure species formed part of the investigations, and the aerial portions of the plants at the flowering stage and at maturity were collected, dried, and analysed.

The 20 species selected for the experiment consisted of 4 legumes, 11 grasses, and 5 miscellaneous species. These species were grown in glazed earthenware pots of 24 kilos capacity, the pots being filled with two parts Waite Institute fallowed loam mixed with one part Gawler River sand. Superphosphate was added at the rate of 500 lb. per acre. Five plants were sown in each pot. There were 8 replications of each species, 4 of which were harvested at the flowering stage and 4 at maturity, but in certain instances, e.g., *Atriplex*, in which the appearance of flowers and the state of maturity are somewhat uncertain (maturity being indicated by the presence of fully matured seed), a

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final harvest was made at a definite date (31st December, 1931). The pots were sown on 8th and 9th May, 1931, and, throughout the growing period, the moisture content of the soil was adjusted to 56 per cent. of its total water-holding capacity. All plants were harvested at the surface of the soil, and only the aerial portions thus obtained were submitted to analysis. In 9 cases, seeds were collected and analysed separately. The conventional methods of analysis have been adhered to. Total ash results are all CO_2 free, since, owing to the variation in the CO_2 content of the ash as ordinarily estimated, this is more suitable for purposes of comparison. Results are expressed as percentages on a dry-matter basis, except where otherwise stated.

The final section of the paper deals with total dry matter elaborated at flowering, contrasted with that present at maturity; the dates of harvesting are also given, as wide intervals exist between the onset of flowering in the several species. The time between flowering and maturity also varies considerably for different species.

The species selected for experiment were as follows:—

I. Legumes—

Medicago denticulata (Toothed medic, burr trefoil).
Trifolium subterraneum (Subterranean clover).
Trifolium fragiferum (Strawberry clover).
Trifolium repens (White clover—New Zealand type).

II. Grasses—

Hordeum sativum (Barley, var. Cape).
Hordeum murinum (Barley grass).
Lolium spp. (Wimmera rye-grass).
Lolium multiflorum (Italian rye-grass).
Lolium perenne (Perennial rye-grass).
Phalaris tuberosa (Toowoomba canary grass).
Phalaris minor (Annual canary grass).
Dactylis glomerata (Cocksfoot).
Holcus lanatus (Yorkshire fog).
Danthonia semiannularis (Wallaby grass).
Danthonia Duttoniana (Brown-seeded wallaby grass).

III. Miscellaneous—

Erodium botrys (Wild geranium, Heron's bill).
Atriplex vesicarium (Bladder saltbush).
Atriplex semibaccatum (Creeping saltbush, berry saltbush).
Cichorium intybus (Chicory).
Plantago lanceolata (Plantain, rib grass).

The aerial portions of each species were collected at the flowering stage and at maturity.

2. Chemical Composition of whole Aerial Portions of Plants.

The following table summarizes the proximate composition of the 20 species at the flowering stage and at maturity:—

TABLE I.—PROXIMATE CHEMICAL COMPOSITION OF TWENTY SPECIES OF PASTURE PLANTS AT THE STAGE OF (*a*) FLOWERING, (*b*) MATURITY, WHEN GROWN UNDER IDENTICAL CULTURAL CONDITIONS.

Species.	Flowering Stage.					Mature Stage.				
	Crude Protein.	Crude Fibre.	Ether Extract.	N-free Extractives.	Total Ash.	Crude Protein.	Crude Fibre.	Ether Extract.	N-free Extractives.	Total Ash.
I. LEGUMES.										
M. denticulata ..	29·00	16·23	1·48	41·99	11·30	17·19	29·83	2·48	43·98	6·52
T. subterraneum ..	19·50	22·54	2·23	44·92	10·81	12·00	27·78	2·71	48·55	8·96
T. fragiferum[2] ..	16·69	14·97	0·91	60·19	7·24	13·50	15·88	0·95	62·19	7·48
T. repens	21·94	15·76	1·08	52·17	9·05	12·31	18·58	1·26	60·10	7·75
II. GRASSES.										
H. sativum	7·12	30·02	0·97	52·62	9·27	5·50	22·53	1·53	62·98	7·66
H. murinum	10·44	26·32	1·50	52·03	9·71	6·69	30·80	1·50	52·98	8·03
Lolium spp. (Wimmera rye-grass)	4·56	29·15	0·91	58·60	6·78	5·38	32·07	1·56	52·67	8·32
L. multiflorum ..	4·69	26·93	1·00	59·74	7·64	4·88	28·42	1·57	56·75	8·38
L. perenne	6·25	29·63	1·45	53·80	8·87	5·50	27·86	1·57	56·72	8·35
P. tuberosa	5·25	33·15	1·42	51·53	8·65	4·88	30·27	2·26	55·12	7·47
P. minor	5·44	24·26	1·03	61·00	8·27	4·69	28·46	2·71	56·05	8·09
D. glomerata	5·81	25·97	2·30	57·02	8·90	5·38	24·64	2·75	58·43	8·80
H. lanatus	6·88	25·94	1·66	56·26	9·26	4·25	26·51	1·80	59·31	8·13
D. semiannularis ..	12·00	33·59	1·12	45·90	7·39	8·94	35·67	1·48	47·91	6·00
D. Duttoniana ..	13·44	30·78	1·24	46·24	8·30	9·44	34·20	1·59	47·75	7·02
III. MISCELLANEOUS.										
E. botrys	23·00	12·43	1·60	47·92	15·05	10·93	31·23	3·26	44·36	10·22
A. vesicarium[1] ..	8·00	27·35	1·04	48·62	14·99	6·08	30·48	1·28	46·09	16·09
A. semibaccatum[2] ..	8·38	28·73	1·26	51·19	10·44	5·37	26·95	1·03	52·42	14·23
C. intybus[3]	9·75	21·81	3·40	51·52	13·52	11·25	14·40	5·30	51·43	17·62
P. lanceolata	10·88	17·70	1·12	58·10	12·20	5·56	26·95	1·70	56·38	9·41

1. The analysis of *A. vesicarium* is from one plant only at flowering stage, since none of the other plants of that species flowered even up to the date of the final harvest (31st December, 1931). The analysis in the maturity table is therefore from non-flowering plants.
2. These species had flowered, but no matured seeds were present when the final harvest was taken; the analyses given are, therefore, from plants not fully matured.
3 *C intybus* is a biennial, but three plants flowered in the first year of growth, and the results at flowering stage are for these plants; the analysis shown in the maturity table is for non-flowering plants collected at the date of terminating the experiment (31st December, 1931).

A striking feature of the proximate analysis is the wide variation in chemical composition between the species within each group, and between groups of species. This is especially marked in regard to crude protein, which is one of the most important of the plant constituents. *Medicago denticulata* (burr clover) with 29.00 per cent. of crude protein on a dry-weight basis at flowering may be contrasted with Wimmera rye-grass at the same stage of growth with only 4.56 per cent.

A feature of special interest is the difference in protein and ash content of the legumes, grasses, and miscellaneous species at flowering. The range of protein content for the legumes is from 29.00 per cent. to 16.69 per cent.; the range covered by the grasses is from 4.56 per cent. to 13.44 per cent., the majority showing 7 per cent. or less. The grasses therefore have, in general, a considerably lower protein content than the legumes. Amongst the miscellaneous species investigated, only *Erodium botrys* has a very high protein content. This species begins flowering at a very early stage of growth, and continues to form flowers for a fairly long period. The first appearance of flowers in this species coincides with a very early stage of plant development, and this probably accounts for the high protein and ash content, and low fibre, relatively to dry matter, in this species.

M. denticulata also commences to flower very early in its growth period, and its high protein and ash content and low dry matter may be attributed to the same cause (*vide* section 4).

At maturity, the variation is of a similar type. The high protein content of the legumes is again in evidence. The miscellaneous species show high ash values and the grasses relatively low ones, while three of the legumes have similar ash percentages to the grasses; *T. subterraneum*, however, maintains a relatively high figure both at flowering and maturity.

Another feature of interest is the marked drift with time of the mean protein content of each group. This is shown in the following comparison: (Chicory has been excluded from the mean value for the miscellaneous group—*vide* note below Table I.).

	Per cent. of Crude Protein.	
	Flowering.	Maturity.
Legumes	21.78 ..	13.75
Grasses	7.44 ..	5.96
Miscellaneous ..	12.57 ..	6.98

On the other hand, crude fibre increases materially with time in the legumes and miscellaneous species, but not to such a marked degree in the grasses. The total ash shows a drift to lower values with legumes and grasses towards maturity, but, with the miscellaneous types, there is an increase in total ash with the saltbushes, and a substantial fall in ash content with *Erodium* and *Plantago*.

Generally speaking, the characteristic fall in the protein content as the plant advances towards maturity is accompanied by a rise in fibre and nitrogen-free extractives, and, with some miscellaneous species, an increase in total ash.

Ether extract (fat) in each group and with each individual species in the group increases as the plant advances from flowering to maturity.

The nitrogen, phosphoric acid, and soluble and insoluble ash content of the species at each stage are summarized in the following table:—

TABLE II.—NITROGEN, PHOSPHORIC ACID, AND ASH CONTENT OF 20 SPECIES OF PASTURE PLANTS WHEN GROWN UNDER IDENTICAL CONDITIONS.

Species.	At Flowering.				At Maturity.			
	N.	P_2O_5.	Soluble Ash.	Insoluble Ash.	N.	P_2O_5.	Soluble Ash.	Insoluble Ash.
I. LEGUMES.								
M. denticulata	4·64	0·61	10·98	0·32	2·75	0·44	6·28	0·24
T. subterraneum ..	3·12	0·50	10·45	0·35	1·92	0·35	8·61	0·35
T. fragiferum[2]	2·67	0·60	6·90	0·34	2·16	0·54	7·11	0·37
T. repens	3·51	0·75	8·51	0·54	1·97	0·52	7·36	0·39
II. GRASSES.								
H. sativum	1·14	0·38	8·02	1·25	0·88	0·39	5·56	2·10
H. murinum	1·67	0·42	7·93	1·78	1·07	0·40	5·72	2·31
Lolium spp. (Wimmera rye-grass)	0·73	0·33	5·41	1·37	0·86	0·41	5·99	2·33
L. multiflorum	0·75	0·35	5·98	1·66	0·78	0·38	6·12	2·26
L. perenne	1·00	0·36	7·01	1·86	0·88	0·37	6·03	2·32
P. tuberosa	0·84	0·30	6·94	1·71	0·78	0·30	4·77	2·70
P. minor	0·87	0·27	6·97	1·30	0·75	0·29	5·86	2·23
D. glomerata	0·93	0·35	7·07	1·83	0·86	0·29	6·76	2·04
H. lanatus	1·10	0·42	6·57	2·69	0·68	0·35	5·41	2·72
D. semiannularis ..	1·92	0·38	4·98	2·41	1·43	0·32	3·56	2·44
D. Duttoniana	2·15	0·42	5·43	2·87	1·51	0·36	4·62	2·40
III. MISCELLANEOUS.								
E. botrys	3·68	0·71	13·83	1·22	1·75	0·65	9·24	0·98
A. vesicarium[1] ..	1·28	0·52	14·58	0·41	0·97	0·46	15·32	0·57
A. semibaccatum[2] ..	1·34	0·45	9·99	0·45	0·86	0·39	13·09	1·14
C. intybus[3]	1·56	0·47	12·61	0·91	1·80	0·33	16·35	1·27
P. lanceolata	1·74	0·46	11·67	0·53	0·89	0·30	8·62	0·79

1, 2, 3—See notes below Table I.

A marked drift in the phosphoric acid content occurs with the leguminous species, and to a lesser extent with the miscellaneous species, as the plants mature, but with the grass species, there is very little difference in the phosphoric acid content at maturity as compared with flowering.

The legumes give distinctly higher percentages of phosphoric acid than do the grasses at both stages of growth; the miscellaneous species more nearly approach the legumes at flowering stage.

Erodium botrys is outstanding in having the highest P_2O_5 content of any of the species recorded both at flowering and maturity; its soluble ash content is also very high at both growth stages.

The values for soluble ash are in general lower at maturity for legumes and grasses, but the miscellaneous species follow the same

trend as was observed in the case of the total ash in Table I. The strikingly low values for insoluble ash in the case of the legumes and of some of the miscellaneous species, as compared with the grasses, are worthy of note. *Erodium botrys,* however, approaches the grasses for this constituent at flowering. The general tendency is, in the cases of the grasses and of the miscellaneous species, except *E. botrys,* for insoluble ash to increase as the age of the plant advances; with the legumes, the tendency is to remain constant or even to fall off.

3. Chemical Composition of (*i*) Leaf and Stem, and (*ii*) Seed.

In 9 of the species, leaf and stem was separated from seed, or the normally dehiscent portion containing the seed, and each portion analysed separately. Owing to the impracticability of removing the appendages of the seeds these are present in all cases, save those of *T. subterraneum* and *T. repens* in which the appendages are naturally separated during threshing, and added to the leaf and stem portion. The "seed" or fruit portion of *M. denticulata* includes the "burrs," the flowering glumes or paleae in four of the grasses, the unskinned grain in barley, and the awned fruits of *E. botrys.* In the two species of *Trifolium,* true seeds were analysed.

The results of the analyses are shown in Tables III. and IV.

Table III.—Proximate Chemical Composition of Leaf and Stem Contrasted with that of "Seed."

Species.	Crude Protein.		Crude Fibre.		Ether Extract.		N-free Extractives.		Total Ash.	
	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.
I. Legumes.										
M. denticulata ..	8·00	22·88	27·02	31·57	1·50	3·09	54·01	37·76	9·47	4·70
T. subterraneum ..	9·13	39·63	29·73	9·01	1·42	15·16	50·30	31·63	9·42	4·57
T. repens	11·50	30·75	18·83	12·94	1·05	5·99	60·76	44·90	7·86	5·42
II. Grasses.										
H. sativum	3·00	9·69	31·70	6·53	1·68	1·29	52·96	79·88	10·66	2·61
H. murinum	3·25	10·50	34·32	26·85	1·73	1·25	50·72	55·55	9·98	5·85
P. minor	2·69	15·31	32·34	7·84	1·79	7·60	54·69	63·26	8·49	5·99
D. semiannularis ..	5·88	17·94	40·52	22·24	1·35	1·88	45·96	52·77	6·29	5·17
D. Duttoniana ..	7·00	17·56	38·38	20·12	1·39	2·28	45·55	55·24	7·68	4·80
III. Miscellaneous.										
E. botrys	9·38	12·75	24·60	38·49	1·96	4·69	48·50	39·69	15·56	4·38

Table III. illustrates the well-known fact that higher concentrations of protein occur in seed than in leaf and stem. Both the seeds and leaf and stem portions of the legumes are richer in protein than are those parts of the grasses.

The results for fibre in *M. denticula* and *E. botrys* are comparatively high, owing to the inclusion of the burrs with the seeds in each case. Fibre values are distinctly higher in leaf and stem portions of grasses than they are in the corresponding portions of legumes.

The usually observed superiority of seed over leaf and stem, in ether extract, is made evident in the table, but the two species of *Hordeum* apparently deviate from the general trend.

The seeds of the legumes are richer in fat than those of most of the grasses, but *P. minor* is conspicuous with the remarkably high value (for a grass) of 7.6 per cent. *T. subterraneum* is most prominent with 15.16 per cent. The result for *T. subterraneum* may be compared with published average analyses for such well known fat-bearing seeds as soy beans (17.5 per cent.) and cotton seed (19 per cent.)* *P. minor* may be compared with oats, containing 4.4 per cent. fat, which is one of the highest values given by the same authorities for a species suitable for comparison with *Phalaris*.

TABLE IV.—THE NITROGEN, PHOSPHORIC ACID, SOLUBLE ASH AND INSOLUBLE ASH CONTENT OF LEAF AND STEM CONTRASTED WITH THAT OF "SEED."

Species.	Nitrogen.		Phosphoric Acid.		Soluble Ash.		Insoluble Ash.	
	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.	Leaf and Stem.	Seed.
I. LEGUMES.								
M. denticulata	1·28	3·66	0·16	0·61	9·01	4·60	0·46	0·10
T. subterraneum	1·46	6·34	0·22	1·65	9·04	4·46	0·38	0·11
T. repens	1·84	4·92	0·48	1·50	7·47	4·98	0·39	0·44
II. GRASSES.								
H. sativum	0·48	1·55	0·13	0·83	7·64	2·06	3·02	0·55
H. murinum	0·52	1·68	0·11	0·73	7·83	3·35	2·15	2·55
P. minor	0·43	2·45	0·13	1·12	6·46	2·70	2·03	3·29
D. semiannularis ..	0·94	2·87	0·19	0·69	3·90	2·57	2·39	2·60
D. Duttoniana	1·12	2·81	0·20	0·88	5·13	2·91	2·55	1·89
III. MISCELLANEOUS.								
E. botrys	1·50	2·04	0·35	0·97	13·82	4·24	1·74	0·14

In all cases, the very high concentration of phosphoric acid in seed as compared with that in leaf and stem is apparent. *Phalaris minor* with 1.12 per cent. P_2O_5 in its seed is conspicuous amongst the grasses.

Soluble ash is in all cases considerably less in seed than in leaf and stem, while the seed of the leguminous group shows distinctly higher values than are found for the grasses.

The insoluble ash of the legumes, both in leaf and stem and in seed, is considerably less than that of the grasses.

The nitrogen, phosphoric acid, and soluble ash content of the leaf and stem of *E. botrys* are worthy of note; the nitrogen and P_2O_5 results are similar to that found for legumes, while the soluble ash is the highest recorded in the table. The seed of *E. botrys*, however, is not specially rich in nitrogen, but has medium P_2O_5 content.

* Henry and Morrison—"Feeds and Feeding."

4. Dry Matter Production.

Table V. shows the number of grams of dry matter produced for each period of growth; in the cases of the 9 species in which seed was separated, the weights of dry matter of leaf and stem, contrasted with those of seed, are also given; the figures indicate mean dry matter per pot. The pots were sown on the 8th and 9th May, 1931, and the harvesting dates are included in the table.

TABLE V.—SHOWING THE NUMBER OF GRAMS OF DRY MATTER PRODUCED FOR EACH PERIOD OF GROWTH.

Species.	Flowering.		Maturity.			
	Date of Harvest.	Total D.M.	Date of Harvest.	D.M. of Leaf and Stem.	D.M.[4] of Seed.	Total D.M.
I. LEGUMES.						
M. denticulata ..	17.8.31	17·2	7.11.31	64·7	104·6	169·3
T. subterraneum ..	5.10.31	89·5	3.12.31	156·3	16·3	172·6
T. fragiferum[1] ..	5.12.31	78·8	31.12.31	..	..	97·9
T. repens	17.10.31	52·4	12.12.31	120·2	5·3	125·5
II. GRASSES.						
H. sativum	18.9.31	191·8	12.11.31	203·6	120·8	324·4
H. murinum	16.9.31	82·2	24.11.31	78·8	70·4	149·2
Lolium spp. (Wimmera rye-grass)	24.10.31	199·3	10.12.31	..	..	183·1
L. multiflorum ..	10.11.31	182·5	20.12.31	..	..	206·2
L. perenne	8.11.31	137·7	20.12.31	..	..	186·7
P. tuberosa	18.11.31	149·0	31.12.31	..	..	191·2
P. minor	18.10.31	157·9	3.12.31	160·5	30·3	190·8
D. glomerata	28.11.31	150·4	31.12.31	..	..	173·6
H. lanatus	13.12.31	161·7	31.12.31	..	..	192·0
D. semiannularis ..	26.10.31	75·5	11.12.31	89·5	30·5	120·0
D. Duttoniana ..	23.10.31	64·0	11.12.31	85·1	25·3	110·4
III. MISCELLANEOUS.						
E. botrys	31.8.31	20·7	12.11.31	50·2	46·0	96·2
A. vesicarium[2] ..	24.12.31	152·3	31.12.31	..	..	158·0
A. semibaccatum[1] ..	25.11.31	124·8	31.12.31	..	..	150·4
C. intybus[3]	24.12.31	76·0	31.12.31	..	..	59·4
P. lanceolata	22.10.31	95·8	12.12.31	..	..	153·5

1. Plants had flowered but produced no seed at time of maturity harvest (termination of experiment). Dry-matter results are therefore mainly from non-flowering plants at both harvest dates.

2. Flowering analysis from one plant only; remainder had not flowered at termination of experiment. Dry-matter results are, therefore, mainly from non-flowering plants at both harvest dates.

3. Results are from first year non-flowering plants. The growth of this species was irregular.

4. See opening paragraph, section 3.

5 Acknowledgment.

The author wishes to express his thanks to Mr. H. C. Trumble, M.Agr.Sc., under whose direction the cultural part of this work was carried out.

PLATE I.

"A Note on the Origin of 'Toowoomba Canary Grass' (*Phalaris tuberosa L*)." (See page 195.)

FIG. 1.—Selected strain of *P. tuberosa* (left–P30), two rows of parental *P. tuberosa* (left centre) and fourth generation hybrid derivatives from the initial cross *P. arundinacea* x *P. tuberosa* followed by back-crossing to *P. tuberosa* (centre and right). Parental *P. tuberosa* and fourth generation hybrid derivatives from seed kindly supplied by Dr. T. J. Jenkin.

FIG. 2.—Perennial *P. minor* hybrid type occurring naturally in the Waite Institute collection.

PLATE II.

"A Note on the Origin of 'Toowoomba Canary Grass' (*Phalaris tuberosa L*)." (See page 195.)

FIG. 3.—Second generation derivatives from a natural *P. tuberosa* x *P. minor* cross. The plants are in the second year, and the shears indicate where an annual type has disappeared.

FIG. 4.—*P. tuberosa* type—perennial.

FIG. 5.—Dense leafy perennial hybrid type with materially enhanced vigour.

PLATE III.

"A Note on the Origin of 'Toowoomba Canary Grass' (*Phalaris tuberosa L*)." (See page 195.)

FIG. 6.—Grass tuft type; short-lived perennial.

FIG. 7.—Stemmy, short-lived perennial, approaching *P. minor* type.

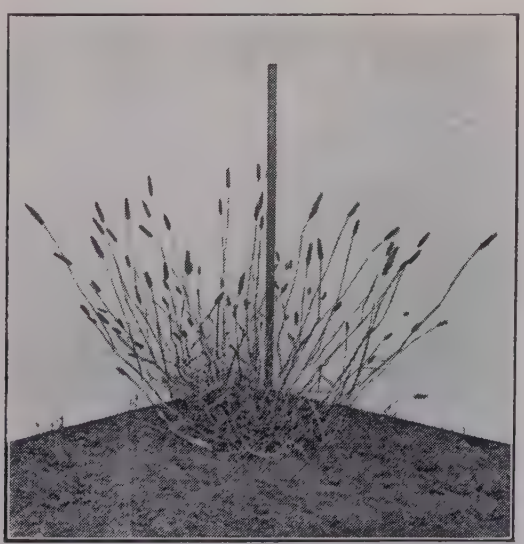

FIG. 8.—*P. minor* type—annual.

FIGS. 4–8.—Third generation derivatives from a natural *P. tuberosa* x *P. minor* cross. The plants are in their first year.

"Downy Mildew (Blue Mould) of Tobacco: Its control by Benzol and Toluol Vapours in covered Seed-beds." (See page 203.)

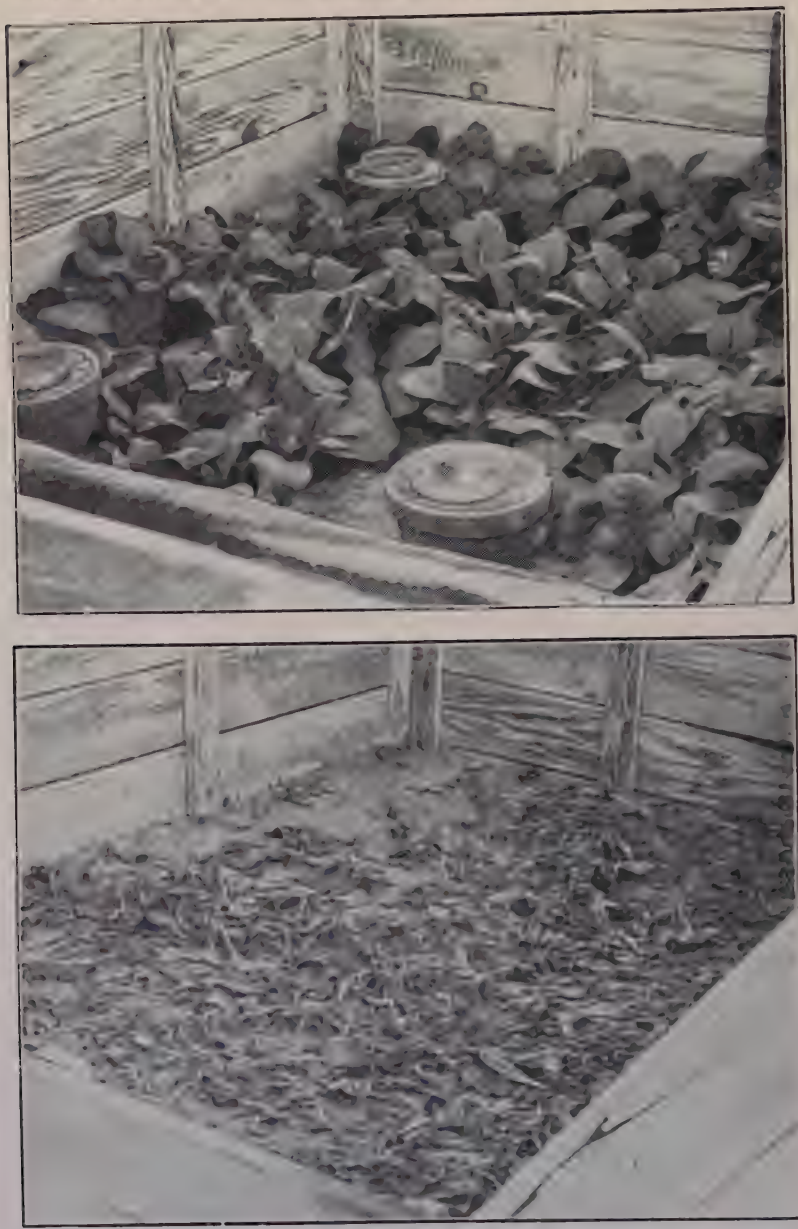

FIG. 1 (top). Seedlings protected by benzol vapours. They were exposed to infection from nearby diseased plants from the 1st April, and were also deliberately inoculated on the 12th, 15th, and 25th April. Some of transplantable size were removed on the 7th May. The others were pulled and examined on the 4th June. No downy mildew was observed at any time

FIG. 2 (bottom). Remains of plants in the control bed two feet away. Both photographs were taken on the 22nd May.

A Note on the Origin of "Toowoomba Canary Grass" (*Phalaris tuberosa* L.)

*By H. C. Trumble, M.Agr.Sc.**

The article that follows discusses work which forms a part of the co-operative programme of investigations in which the Waite Agricultural Research Institute of the University of Adelaide, the Carnegie Trust, and the Council for Scientific and Industrial Research are now co-operating. The Empire Marketing Board also contributed to the scheme for some years (see this *Journal*, Vol. 5, No. 3, August, 1932, p. 141). When the Board was disbanded, and its contributions ceased, the Carnegie Trust contributed a sum of £1,750 for one year and a sum of £900 for a second year towards the cost of the investigations, conditional on an undertaking being given that the work would be continued after the close of the second year. (See this *Journal*, Vol. 7, No. 2, May, 1934, p. 114.)—Ed.

Summary.

An early and hitherto unnoticed report dealing with the "Toowoomba canary grass" has been located and re-published.

The available literature relating to the origin of this grass has been reviewed and its early history interpreted in the light of this information and of field observations made at the Waite Institute.

The grass appears to have been introduced under the name "*Phalaris commutata*," and it is assumed that it was obtained from Italy by the New York Department of Agriculture and forwarded to Toowoomba about 1884.

Botanical and agronomic examination indicate that the grass is the same taxonomically as *P. tuberosa* L., but is greatly superior for agricultural purposes to those forms of the species which have so far been obtained direct from Mediterranean countries. Hand-crossing between Mediterranean and Australian material indicates that the two types are completely compatible, and give rise to normal progeny of *P. tuberosa*.

1. Introduction.

The nature of the climatic environment of much agricultural and pastoral country in South Australia has tended to preclude the development of herbage plants common to more temperate regions, and to favour the use of species and strains adapted to climatic conditions of the Mediterranean type.

Three plants which have become closely identified with pasture improvement work in this State are subterranean clover, Wimmera rye-grass, and *Phalaris tuberosa*. The first two are annuals; the third is perennial. All appear to have been derived, directly or indirectly, from the herb-flora of Southern Europe.

The introduction of subterranean clover into South Australia was apparently accidental, and no information is available as to when and how it first became established. The same remarks apply to many other plants which have come to Australia from foreign lands.

Wimmera rye-grass was first observed in Victoria, and, as far as can be ascertained, it originated from European material. The grass was known in the Wimmera district as Italian rye-grass for many years.

The early history of *Phalaris tuberosa* has been in much doubt since attention was first drawn to its agricultural possibilities early in the present century. Since Ewart's paper (1) in 1908, this grass, known

* Agronomist, Waite Agricultural Research Institute.

successively as "*Phalaris commutata,*" "Toowoomba canary grass," "*Phalaris bulbosa,*" and most recently by its accepted botanical name, *Phalaris tuberosa,* has been the subject of much speculation, and several theories have been put forward to explain its origin.

Investigations of the grass at the Waite Institute have resulted in the accumulation of much first-hand information which permits an interpretation of the recorded facts of previous years with a greater degree of certainty.

2. Historical.

The two well-known early papers concerning the Toowoomba grass are those of Ewart, 1908 (1), and Kennedy, 1917 (2). In recent years, Allan and Zotov, 1930 (3), Jenkin (4), and Trumble, 1934 (5), have described and interpreted its history in the light of the information that was available to them. The writer has been fortunate in locating a published report of the grass (6) which is earlier than Ewart's paper, and which supplies direct evidence from the pen of R. Harding, who first distributed the grass from Toowoomba.

It seems desirable to re-publish this early report *verbatim et in toto,* owing to the limited opportunities for ready access to the original. The following is the report as it appeared in *The Garden and Field* (Adelaide and Melbourne), 19th November, 1904, p. 196:—

"*Phalaris commutata.*

'A New Fodder Grass.

'The Curator of the Toowoomba Botanic Gardens, Queensland, in his report, says:—

'In 1884 I received a number of packets of grass seeds from the Department of Agriculture, America. These were sown in drills, and all germinated and made good growth until the first frost, which killed all except one, named "Phalaris commutata." Requiring the ground space for other purposes, I removed this grass and simply dumped it into a corner of the nursery, taking no particular care of it. Although the ground was very hard, it made tremendous growth in one year, germinated where it had fallen, and in one year some grew into clumps 2 feet across and 5 feet in height, with nice, soft, succulent blades up the flowering stems. This has been cut two and three times in the year.

'The roots are fibrous, the foliage very dense, a bright-green (especially during the winter), of a similar nature to "Phalaris canariensis," but much more productive. Visitors from all parts of the Commonwealth who were shown this grass were surprised how it withstood the drought.

'To graziers and dairymen I particularly recommend it, it being productive throughout the year. It is easily propagated, and when once started it will soon produce seed which, if allowed to shed, will germinate freely. The seed is small and glossy. During the '93 flood the roots were in a bog for six weeks, and the only difference it made was the foliage was slightly yellow, but kept growing all the time. It seems to like all kinds of weather, and from the rapidity of its growth it excels all other grasses I have had anything to do with.

'What it would be if properly cultivated it is hard to say, but it is a very desirable grass to introduce and distribute. By its own self-sowing it has covered a large space of ground in the nursery. It is as much at home under the shade of trees (growing close to the trunks) as it is in the open, the ground in some places being as hard as a rock. I beg to suggest that a plot of ground be prepared outside the nursery, convenient to public view, and that this grass be planted for the purpose of distribution, and that publicity be given that plants can be obtained at the gardens. I have at the present time a sheaf of this grass, cut when green, 6 feet in length, which can be seen on application."

It would appear from Ewart's paper (*loc. cit.*) that Mr. R. Harding was Curator when the grass first received publicity, but that the seed

was obtained when Mr. Way was Curator. It seems, however, that Harding was employed at the gardens at the time of the introduction.

According to Ewart, "*Phalaris commutata*" was a native of the foothills of the Alps and other parts of Italy. It appeared that this Italian grass had been imported into Queensland from America in 1884, with other grasses. In a letter from Harding, quoted by Kennedy (*loc. cit.*), the original seed was stated to have been obtained from Italy. The evidence we have then is—(i) from Harding direct, that the seed was obtained from the "Department of Agriculture, America"; (ii) from Ewart, that "*Phalaris commutata*" was a native of Italy, but that the grass was imported from the Agricultural Department of New York, U.S.A.; and (iii) from Harding, via Kennedy, that it was received from Italy. Dr. A. J. Pieters, Principal Agronomist, United States Department of Agriculture, states in a private communication that the New York State Department of Agriculture was, in past years, quite active in securing samples of seed from overseas and in making distributions. It seems reasonable to suppose that the seed in this particular case was obtained from Italy by the New York State Department of Agriculture and was forwarded, with other grasses, to the Toowoomba Botanic Gardens.

The packet of seed was originally labelled "*Phalaris commutata,*" which would indicate Italian origin. This name, according to Ewart, was given by Roemer and Schultes to a plant gathered near Genoa (Italy). The Italian botanist, Bertolini, however, rejected the name "*commutata*" on the ground that the specimen was combined of the vegetative parts of *P. bulbosa* (= *P. tuberosa*) and the inflorescence of *P. minor*. This led to a suppression of the name *P. commutata*. It is of interest to note that Hackel, owing in part to the absence of an appendage to the lower sterile floret (an essential taxonomic feature of *P. minor*) in material sent to him from Australia by Professor A. J. Ewart, gave the name *P. stenoptera* (nov. spec.) to the grass. Kennedy (2) was not able to confirm Hackel's observations regarding the lower sterile floret, and made the suggestion, more recently supported by Allan and Zotov (3), that Ewart's material was mixed, containing vegetative parts of the perennial species and florets of *P. minor*, in much the same way as Bertolini's specimen of "*P. commutata*" was supposed to have been mixed. The writer has observed *P. minor* characteristics, chief among which is the absence of the appendage to the second sterile floret, in pedigreed material of *P. tuberosa*, and puts forward the suggestion that both Bertolini's and Ewart's specimens were authentic specimens of *P. tuberosa* and not mixed, as has been assumed.

Two main theories have been put forward to explain the origin of this grass. Firstly, there is the theory of hybrid origin, suggested by Ewart and by Kennedy. Kennedy stressed the fact that Hackel had traversed southern Europe many times, yet had not previously known the grass; in his description, naming the plant *P. stenoptera* Hack., he added "*Patria ignota.*" This theory was rejected by Allan and Zotov because they were unable to find any evidence to support it, but was later revived by Jenkin, who was able to obtain fertile hybrids between *P. arundinacea* L. and *P. tuberosa*, and to derive attractive agricultural types by back-crossing to *P. tuberosa*. Observations at the Waite Institute have indicated that there are close affinities between the three forms *P. arundinacea*, *P. tuberosa*, and *P. minor*, each of which possesses fourteen chromosomes, and the three possible inter-specific crosses have

each been successfully accomplished. *Phalaris tuberosa,* as it is known in southern Australia, however, has yet to be produced by artificial hybridization.

The second theory is that the Australian forms are variants or ecotypes isolated from populations naturally occurring in the Mediterranean region. Stapf, in 1909 (quoted by Jenkin), came to the conclusion that the grass was of Mediterranean origin, after examining material forwarded by Ewart.

So far as the theory of hybrid origin is concerned, the general assumption has been that hybridism would have occurred in Australia between other species of *Phalaris* following the introduction of one parent in 1884. According to Harding's original report (1904) herein reproduced, and his letter to Kennedy, the grass grew readily from seed, and was conspicuous practically from the outset: " . . . in two years it had taken possession of nearly the whole plot of ground in the nursery."(2) These facts, together with the strong possibility that Bertolini's specimen was authentic, tend to suggest that we must look farther back than Toowoomba for the origin of the grass, whether it arose from hybridism or not.

3. Evidence from Artificial Hybridization.

During the 1932 and 1933 seasons, hand-crosses were carried out at the Waite Institute between the majority of the *Phalaris* species which were then available.*

The results obtained are summarized in Table I.

TABLE I.—SHOWING THE RESULTS OF INTER-SPECIFIC PHALARIS CROSSES CARRIED OUT BY HAND DURING THE 1932 SEASON.

Cross.		Number of Separate Crosses.	Seeds Obtained.	Seeds Planted.	Seedlings Obtained.	Seedlings with Pink ‡Root Tip.	Seedlings with White Root Tip.‡	Number of Surviving Plants.	
♀	♂							1st Year.	2nd Year.
P. arundinacea ..	*P. *minor* ..	6	373	324	113	9	..	59	8
P. arundinacea ..	*P. *coerulescens*	1	6	6	1	0	..	1	1
P. arundinacea ..	*P. *tuberosa* (S.A.)	2	44	25	17	0	..	17	8
P. tuberosa (S.A.)	*P. *minor*	2	71	55	22	13	..	0	0
P. tuberosa (S.A.)	*P. *coerulescens*	1	1	1	1	0	..	1	1
P. tuberosa (Palestine)	*P. *tuberosa* (S.A.)	1	40	20	20	0	..	20	20
P. coerulescens ..	*P. *paradoxa* ..	2	0	0	0	0	..	0	0
P. coerulescens ..	*P. *minor* ..	1	89	70	50	11	..	37	4
P. coerulescens ..	*P. *tuberosa* (S.A.)	2	60	38	26	0	..	0	0
P. coerulescens ..	*P. *arundinacea*	1	0	0	0	0	..	0	0

‡ The germination of *Phalaris* seeds is frequently poor on filter paper. Approximately half the seeds were sown in sterilized soil, therefore, and were not examined for colouration of the root tip. The remaining seeds germinated poorly and gave comparatively few seedlings for root tip examination.

The somatic chromosome numbers for the respective parent species are as follows† :—

7—*P. coerulescens, P. paradoxa.*
14—*P. arundinacea, P. tuberosa, P. minor.*

* Grateful acknowledgment is made to Mr. A. B. Cashmore, B.Sc., for assistance in making the hand crosses.

† From determinations carried out at the Waite Institute, by I. F. Phipps and F. S. Oldham.

Hybridization was readily effected in most cases, the only exceptions being *P. coerulescens* x *P. paradoxa* and *P. coerulescens* x *P. arundinacea.* Satisfactory yields of seed and moderate numbers of seedlings were obtained with *P. minor* used as a male parent on *P. arundinacea, P. tuberosa,* and *P. coerulescens,* and with *P. tuberosa* used as a male parent on *P. arundinacea* and *P. coerulescens.* In most cases, however, mortality was high, both in the seedling stage and later in the field. The most vigorous plants in the first year were the *P. coerulescens* x *P. minor* hybrids. These were completely sterile, and the majority died during the first summer. The most persistent of the inter-specific hybrids were the plants obtained as a result of crossing between *P. arundinacea* and *P. tuberosa.* These plants tended to be intermediate in character between the two parental types, but resembled the female parent most closely. The surviving plants in the second year were inferior in vigour to the parental *P. tuberosa,* but superior to the parental *P. arundinacea.*

On the whole, the results of the inter-specific crosses have been disappointing, and, so far as the F_1 and second generation plants are concerned, have given no support for the theory that the Toowoomba grass was derived from hybridism between existing species.

The intra-species cross, *P. tuberosa* (Palestine) x *P. tuberosa* (S.A.), showed complete compatibility between the parents, and the progeny from this hybrid were the only plants to behave as normal fertile individuals. The F_1 plants were uniformly tall and stemmy, as in the Palestine parent, but were of enhanced vigour. The results of this cross support the classification of the Toowoomba grass as *P. tuberosa* L., and indicate that a standard agricultural strain (the male parent employed) derived from the Toowoomba grass, and a representative from a Mediterranean source (the female parent), both fall within the same species group.

Some of the most interesting *Phalaris* hybrids are those of T. J. Jenkin, who has produced fertile fourth-generation derivatives from the cross *P. arundinacea* x *P. tuberosa,* followed by back-crossing to the parental *P. tuberosa.* The writer has previously criticized (5) Jenkin's suggestion that this sequence of events might have led to the origin of the Toowoomba grass. It was intended that the basis of this criticism should be the similarity of the parental *P. tuberosa* to the Toowoomba grass itself, that the parental form was not different from typical examples of *P. tuberosa,* and that the hybrid derivatives trended away from the Toowoomba type compared with the parental *P. tuberosa.* Unfortunately, reference was made in this criticism to photographs of F_1 hybrid plants derived from the cross *P. arundinacea* ♀ x *P. tuberosa* ♂ as being different from Australian *P. tuberosa.* Dr. Jenkin has since pointed out by letter that the forms which he regarded as being similar to certain of the Australian forms occurred only in the second and subsequent generations and not in the F_1, as is quite clear from his paper.

Dr. Jenkin forwarded seed from his parental *P. tuberosa* line and seed to produce fourth-generation derivatives to the Waite Institute early in 1933. These were planted, together with a standard check line of Australian *P. tuberosa,* during the same season, and have now been examined both as first-year and second-year plants. The

parental line is typical of Australian material in general growth form, time of flowering, panicle, and spikelet features. Compared with a standard line, the parental *P. tuberosa* line was slightly less vigorous, a little more uniform, and five days later in panicle exsertion. The fourth-generation hybrid derivative seed germinated well, and 70 plants were established. These showed extreme variability (*vide* Pl. I., Fig. 1), and only three plants were comparable in panicle exsertion and time of flowering to the parental line. Of these three plants, two were inferior to the parental line, and the remaining plant very similar to representatives of the parental line. The remaining 67 plants either failed to survive or were considerably later than, and materially different in growth form from, any of the *P. tuberosa* lines. Three plants have proved attractive in vigour and in type. These are approximately four weeks later than standard material, but could well form the basis of a strain for irrigated areas or areas with an extended growing season.

The production of fertile derivatives from the cross *P. arundinacea* x *P. tuberosa* is of considerable agronomic interest in view of the attractiveness of some plants, and new possibilities are indicated in the breeding of improved strains for irrigated or extended rainfall districts.

4. Natural Hybrids.

Evidence of natural hybridism between *P. minor* and *P. tuberosa* has appeared in the Waite Institute collection of *Phalaris* types. Certain plants which were termed " perennial *P. minor* types " occurred in both selfed and out-crossed lines, and in Australian and Mediterranean material. These plants were short-lived perennials, usually surviving for two, sometimes three, seasons. In common with *P. minor,* they were erect, with papery green leaves, exposed crowns, and pinkish root tips. The head type was intermediate between standard heads of *P. tuberosa* and *P. minor,* and the lower portions of the stems tended to be stoloniferous. Lagging chromosomes were evident at the meiotic division. These plants were to some extent cross-fertile, giving rise to a variety of inferior forms of a short-lived character. They were highly self-sterile, and the few seedlings obtained on selfing were sickly, and died at an early age. An example of this type is given in Pl. I., Fig. 2.

Natural hybridism between *P. tuberosa* and *P. minor* occurred as early as in 1929, when open-pollinated seed was collected from a typical plant of *P. tuberosa,* which had been grown in close proximity to plants of both *P. tuberosa* and *P. minor.* Fifty-two plants were grown from open-pollinated seed, 51 of which were normal, and the remaining plant an outstanding individual for vigour, but to all intents and purposes a typical specimen of *P. tuberosa.* This was selfed in 1930, and out-crossed seed was also collected. All of the progeny plants, including one plant obtained on selfing, developed *P. minor* characters. The majority, but not all, showed a pink colouration of the root tip in the seedling condition. Fifty-two out-crossed progeny were grown, and these showed a range of types which included annual plants similar in appearance to *P. minor* and perennial forms of greatly enhanced vigor, but approaching the growth form of *P. tuberosa.* A view of some of the second generation out-crossed progeny in their second growing season is shown in Pl. II., Fig. 3. From two plants of this group, two

further generations of both selfed and out-crossed progeny have been obtained, and from this material it is hoped to derive a strain of agricultural value. Photographs of forms occurring in the third generation are shown in Figs. 4-8, Plates II. and III. The genetics of this material has not been investigated.

Natural crossing has also occurred between plants of *P. arundinacea* and *P. tuberosa*. The lines of *P. arundinacea* grown at the Waite Institute have proved very variable. Much mortality has occurred, and the surviving plants tend to be much later in maturity than *P. tuberosa*. A sample obtained from Brignoles (France), and sown in 1931, produced plants that were earlier and more vigorous than usual, and in the first year the majority of the plants flowered before certain *P. tuberosa* lines had completed anthesis. From these plants, two generations of out-crossed progeny have been obtained, and certain of these second generation plants, now in their second year, show a distinct approach to the *P. tuberosa* type, with considerably greater vigour than either standard *P. tuberosa* lines, or the Aberystwyth 4th generation derivatives. They are also earlier in maturity than most of the latter, but are still materially later than the majority of *P. tuberosa* lines. It is probable that out-crossing with *P. tuberosa* has occurred in the production of these plants, which are now far removed in type from the original plants of *P. arundinacea;* they offer attractive possibilities for the production of a strain for swampy or irrigated areas.

5. The Theory of Hybrid Origin in the Light of Evidence from Inter-Specific Hybrids.

The theory of hybrid origin has proved attractive to a number of workers, including the present writer, to whom hybridism between *P. arundinacea* and *P. minor* appeared to offer possibilities. As a result of the hand-crossing carried out in South Australia, however, no evidence in support of this view has been obtained. It would appear that hybridism between *Phalaris* species, with production of viable seed, may be effected fairly readily, but if hybridism between the species *P. arundinacea, P. minor, P. coerulescens,* and the native Mediterranean forms of *P. tuberosa* is accountable for the origin of the more attractive agricultural forms of *P. tuberosa,* it is probable that this hybridism took the form of a complex and sustained series of intercrosses, and occurred prior to the introduction of the grass into Australia in 1884.

The theory of hybrid origin, however, appears to have very little of a tangible nature to support it, and must therefore remain a highly speculative one. One of the main difficulties is that we know little of what exists in Mediterranean countries from the pasture viewpoint, although many useful pasture plants grown in southern Australia have originated there. In the absence of any exploration or study of this region in respect to the location of pasture ecotypes adapted to conditions of summer drought, it is very difficult for any theory regarding the origin of the Toowoomba grass to rest on a secure basis. In the meanwhile, it is rational to believe that a range of variants of this species exists in Mediterranean countries, and that a group of such variants,

originally obtained from Italy, was directly responsible for the present collection of forms found in Australia. In the absence of further evidence, this may be accepted as a reasonable explanation for the origin of " Toowoomba canary grass."

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Downy Mildew (Blue Mould) of Tobacco: Its Control by Benzol* and Toluol* Vapours in Covered Seed-beds.

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Summary.

Under the conditions of several tests on a small scale, and three experiments in covered seed-beds during the period 16th November, 1934, to 6th June, 1935, the occurrence of downy mildew on tobacco seedlings was prevented, despite thorough inoculation, by the concentration of benzol vapour produced by an area of liquid equal to, or more than, 2 square inches per square foot of bed. Toluol vapour was almost equally effective. Lower concentrations controlled the spread of the disease.

Under the conditions of the experiments, infection did not develop in treated beds from which the covers were removed on fine days. Experiments under spring conditions are necessary before the methods can be recommended for use on a commercial basis.

1. Introduction.

In Australia, at the present time, a satisfactory means of control of downy mildew (commonly referred to as blue mould), is the most outstanding need of the tobacco-growing industry. The disease usually becomes epidemic wherever the growing of seedlings is undertaken. In Northern Queensland and in Western Australia, the loss is less serious than in Victoria, New South Wales, and southern Queensland, where the disease is particularly destructive, not only in spring, but also in autumn.

In this paper, the results of our experiments on the control of the disease in seed-beds by the vapours of certain hydrocarbons are presented.

The work has been concentrated mainly on a thorough testing of the effectiveness of benzol and toluol vapours under widely varying environmental conditions. Experiments in seed-beds out-of-doors have not yet been made in spring. Until that has been done, the methods are not recommended for commercial application.

2. Effect of the Vapours on Germination of Conidia.

As the conidia of the organism causing downy mildew of tobacco were not available when these investigations were begun in late October, 1934, it was tentatively assumed that the effect of benzene and its homologues on the germination of conidia of other organisms would indicate what might be expected of *Peronospora tabacina* Adam. Consequently, the early germination experiments in water-drop cultures in vessels with the vapours of chemically pure benzene, toluene, and xylene were

*In this paper, the term "benzol" is used to designate the portion of the light-oil distillate of coal tar with initial and final boiling points at 70 deg. C. and 98 deg. C. respectively, and a specific gravity of 0.882 at 60 deg. F. By "toluol" is meant what is known commercially as 90 per cent. toluol.

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made first with *Peronospora* sp. on rhubarb (*Rheum Rhaponticum* L.), and later with *Peronospora* sp. on wallflower (*Cheiranthus cheiri* L.).* After the conidia of *P. tabacina* were tested, confirming the results with the other two species, those of the wheat parasite, *Helminthosporium sativum* P.K.B. from artificial culture, were used whenever the nature of the experiment permitted, because of their reliable, practically uniform, and high percentage of germination. During February, 1935, both organisms were used in some comparative experiments, but the germination of the former was then so erratic that the results were of little, if any, value.

Twenty-four hours' exposure of the conidia of *H. sativum* to vapour from an area of 2 square inches in a bell jar of about 900 cubic inches altogether prevented germination during the period. If, however, the slides with the spore suspensions were removed afterwards to another vessel free of benzene, toluene, or xylene, normal germination of many of the conidia ensued. Other experiments showed that the effect of the vapours on *P. tabacina* was more drastic, nearly all the conidia being killed after less than sixteen hours' exposure.

In covered seed-beds out-of-doors, a few germination experiments were made, using conidia from other sources. Sometimes a few germinated in the drop cultures on glass slides, despite the presence of benzol or toluol vapour. As the disease was not found in the beds, more work is necessary for a satisfactory explanation of the non-occurrence of a slight amount of disease which, judging by that standard, should have been expected.

3. Control of the Disease.

The disease is spread by conidia, which germinate in drops of water on the leaves and penetrate directly (3), (14). Spore germination and penetration must be prevented if the disease is to be controlled. Spraying and dusting are usually without much effect, because, it is generally presumed, of the mechanical difficulty of thoroughly covering the lower surfaces of leaves that are close to, and parallel with, the ground. However, as Mandelson (8) reports that " copper emulsion " and " colloidal copper " gave better control than other sprays under the conditions of his experiments in Queensland, other factors may be involved.

In some of the earliest experiments on the prevention of infection, an unnecessarily large evaporating surface of benzol, toluol, or xylol was used. The high concentration of vapour in the tightly closed containers killed the seedlings after periods of exposure varying from a few hours to three days. On the other hand, low concentrations of the vapour only controlled the rate of spread of the disease. Later work showed that the concentration which slightly injured some of the seedlings in the beds was at least double that necessary to prevent the disease. As the margin of safety was so wide, it was clear that it was unnecessary to take special precautions against injury to the seedlings, if the area of evaporating surface recommended was used in beds with ordinary covers. The latter, however well made, appeared to provide all the ventilation necessary to prevent too high a concentration of vapour. Padding the frames to prevent loss of vapour is an obvious means of effecting control economically, but if that is done, smaller evaporating

* Collected by Dr. B. T. Dickson

surfaces should be used, or the plants would be injured. In the last two outdoor experiments, the covers and the liquids were removed during fine days. Consequently, the seedlings were often unprotected for about seven hours of the day. Since they remained healthy, even though thus exposed, hardening-off in the spring should not present difficulty.

Of the three principal fractions of the light-oil distillate of coal tar, benzol proved to be the most reliable. It consistently prevented infection in all trials in which an evaporating surface of not less than 2 square inches to every square foot was maintained while the covers were in place.

The vapours of benzol and toluol are heavy, and consequently tend to concentrate near the surface of the ground. They are therefore particularly effective in preventing infection of leaves that are close to the ground. The liquids vaporize at ordinary temperature to an extent sufficient to inhibit spore germination. Furthermore, the slowing-up of the rate of vaporization by low temperature is balanced, to some extent, by the slower rate of germination of the conidia (1).

(i) *Preliminary Experiments.*

As a preliminary to, and concomitant with, the outdoor seed-bed experiments, small scale trials were made. The first four successful experiments were made with potted seedlings in bell jars of about 900 cubic inches, and in glass cages of $3\frac{3}{4}$ cubic feet during the period 17th November to 3rd December, 1934, under outdoor conditions. Just before being subjected to the vapours, the seedlings were inoculated by spraying with a suspension of conidia. Sometimes, diseased specimens in pots were kept in the chambers with the healthy ones. Seedlings of the same age and history served as controls.

In the seven subsequent experiments in the laboratory, the same general procedure was followed. The seedlings protected by the vapours invariably remained free from disease. They were usually discarded one to three or more weeks after the control seedlings had died from the disease. Sometimes they were removed to the normal atmosphere, and kept there for further observation. The disease was never observed on them during the first seven days (the ordinary incubation period), but after that they usually contracted it from diseased plants in their immediate vicinity. Later experiments of this nature showed that, if seedlings were infected, the vapours did not prevent the appearance of symptoms of the disease.

(ii) *Cold-frame Experiments.*

Experiment 1.—Seed of the "Warne" variety was sown on 5th December, 1934, in a bed on a site that had been used for downy mildew experiments since 1930. After germination, cold-frames measuring $4\frac{1}{2}$ feet x $5\frac{1}{2}$ feet were placed in position on the bed, and, on 12th January, diseased seedlings were planted in the centre of each frame. Most of the leaves were from $\frac{1}{2}$ inch to 1 inch wide at the time. Only one evaporating dish, $12\frac{1}{2}$ square inches in area, holding either commercial toluol, xylol, or solvent naphtha (65 per cent. xylol, 35 per cent. higher boiling fractions)* was then placed in each of three frames. The liquids were replenished twice per day. Three other frames were left as controls. On examination of the seedlings on the 19th January, the

* Determined by Mr. E. H. Kipps, B.Sc.

disease was found only in the control beds. On the 25th, it was evident on practically every seedling in them, and to a less extent in those treated with naphtha and xylol, whereas there were, relatively, fewer diseased seedlings in the frame with the toluol vapour. It was evident that a larger evaporating surface of toluol was necessary for complete protection of the plants. The seedlings were discarded on the 29th.

Experiment 2.—On the 30th January, sixteen 8-in. cans and about twenty 6-in. pots of healthy seedlings were removed from the greenhouse to each of the six cold-frames that had been used in the previous experiment. A pot of diseased seedlings was placed in the centre of each frame. Four dishes, with a total evaporating surface of approximately 50 square inches, were put in each of four frames, and filled with benzol, toluol, xylol, or naphtha. In another frame, the evaporating surface of toluol was doubled. The vessels were replenished morning and evening until the 20th February. In addition to using the diseased seedlings already mentioned as a source of inoculum, a heavy suspension of conidia was made, and equal amounts sprayed on the seedlings in each bed on the 8th February. During the week following the direct inoculation, the weather was cooler and more humid than usual. Judging by the production of conidia on seedlings growing in the immediately adjoining areas outside, and in the check frame, conditions were almost, if not quite, ideal for the disease. On the 11th February, and succeeding days, the seedlings in the frames were closely examined. Every seedling in the control frame was diseased on the 11th February, and scattered cases were found on the 12th in the frames with xylol and naphtha. All those in the frames with benzol or toluol were healthy, and they remained so. Finally, on the 27th, seven days after the liquids were removed, the seedlings, still healthy, were discarded in order that preparation might be made for another experiment.

Experiment 3.—As the previous experiment showed that downy mildew could be prevented in closed seed-beds in which suitable concentrations of benzol or toluol were present, this experiment was designed to determine what effect the removal of the covers and the liquids on fine days would have on the incidence of the disease. For comparison, four beds were kept closed as in the previous experiment.

Two seed-beds, each 66 feet long by 6 feet wide, were prepared, one on the same site as in the previous experiment, the other 20 yards away. Both were sown on the 1st March. Germination was general on the 11th inst. Partly in order to ascertain the effect of the vapours on very young seedlings, and more especially to insure that the latter would be protected, if possible, from chance infection, the use of benzol, toluol, and motor spirit was begun on the 13th inst., in ten cold-frames that had been distributed over the area. Four other cold-frames, suitably distributed, served as controls. Five of the frames were 15 inches high in front and 30 inches in the back; the corresponding heights of the others were 9 and 21 inches respectively. The plants in the latter were of much better appearance than those in the former. Three types of covers—glass, windolite,* and oiled calico were also tested. The seedlings grown under the latter wilted slightly more during the day than the others. Of the control frames, one was covered with glass, one with windolite, and two with calico. On the 1st April, some pots of

* A proprietary glass substitute.

diseased seedlings from the greenhouse were placed about 13 yards from one row of frames. As disease was not observed in the beds, leaves with conidia were shaken over each frame on the morning of the 12th, the afternoon of the 15th, and again, after watering, on the afternoon of the 26th April. Downy mildew appeared in the beds used as controls on the 15th, 16th, and 28th April. On the 11th May, all the seedlings in the beds observed to be diseased on the 15th and 16th April were dead. On account of the cold weather supervening, some of the seedlings in the other control beds, although covered with conidia, remained moribund until the 31st May, when the experiment was discontinued. The majority had died from the disease. Downy mildew was observed on the 29th April in both the beds in which ordinary petrol was used. All the seedlings in the beds treated with benzol and toluol remained healthy. These details are summarized in Table I.

TABLE I.—SUMMARY OF DATA OF EXPERIMENT 3.

Each cold-frame was 4½ x 5½ feet. Seedlings inoculated on the 12th, 15th, and 26th April.

Cold Frame No.	Cover.		Fungicide.	Evaporating Surface.	Results.
	Type.	Disposition of.			
1	Windolite	Removed on fine days	Benzol ..	50 square inches	No downy mildew
2	Glass ..	,, ,,	,,	50 square inches	,, ,,
3	Calico ..	,, ,,	,,	50 square inches	,, ,,*
4	,, ..	,, ,,	,,	50 square inches, decreasing to 25 square inches	,, ,,
5	,, ..	Closed ..	,,	50 square inches	,, ,,
6	,, ..	Removed on fine days	Toluol ..	50 square inches	,, ,,
7	,, ..	,, ,,	,, ..	50 square inches, decreasing to 25 square inches	,, ,,
8	Glass ..	Closed ..	,, ..	50 square inches	,, ,,
9	Windolite	,, ..	Petrol ..	50 square inches	Downy mildew, 29th April, 1935
10	,, ..	Removed on fine days	,, ..	50 square inches	,, ,,
11	,, ..	,, ,,	None ..	None ..	Downy mildew, 15th April, 1935*
12	Glass ..	,, ,,	,, ..	,, ..	Downy mildew, 16th April, 1935
13	Calico ..	,, ,,	,, ..	,, ..	Downy mildew, 28th April, 1935
14	,, ..	Closed ..	,, ..	,, ..	,, ,,

* See Plate IV., Figs. 1 and 2.

(iii) *Experiments with Commercial Seed Beds, Eurobin, Ovens River Valley, Victoria.*

The main purpose of this experiment was to ascertain whether the proportion of evaporating surface to seed-bed area found adequate for preventing the disease in cold-frames would do equally well in larger beds. Its other features included variations in the area of the surface of the hydrocarbons exposed for evaporation, and the effect of lack of

protection during fine days when the covers were removed, as they would ordinarily be in spring, to harden-off the seedlings for transplanting.

Because the disease was abundant during the autumn on plants in the field, both before and after the crop was harvested, and the climatic conditions were, from the point of view of disease control, at least as exacting as those of spring, if not more so, it was decided that the results would be, for our present purposes, as dependable as if obtained in spring.

The occurrence of the disease was again prevented by the concentration of benzol vapour produced by the area of liquid proportionately equal to that previously found sufficient. The apparent failure of toluol was perhaps due to a greatly reduced rate of vaporization, consequent on the level of the liquid being 2 inches below the rims of the containers. The amount of liquid vaporized was doubled by keeping the cans full, and the spread of the disease was checked.

In a rectangle 125 feet by 97 feet, at Eurobin, were 40 beds of the "Bathurst" type, described by May(9). They were constructed during the previous year. The size of the seed-beds enclosed by the concrete walls was $6\frac{1}{2}$ feet by 20 feet. In front, the walls stood 10 inches, and in the back, 20 inches above the level of the bed. The beds faced almost due north. Six removable frames, on which oiled calico covers were stretched, covered each bed. Their construction allowed somewhat more ventilation than was thought necessary, yet the consumption of benzol and toluol was less than was anticipated from the results of the previous out-door work at Canberra. Discolouration by fungal growth* on the under side of the oiled calico was very noticeable during the three-months period of the experiment. From the appearance of the covers, we concluded that one season's effective service was all that could be expected of them, despite the concentration of vapours that effectively prevented infection of the seedlings by the conidia of *P. tabacina*. It was therefore considered necessary, in the interests of economy, to use some other waterproofing agents in future experiments.

As the area of evaporating surface necessary for the control of the disease in these beds was yet problematical, no more elaborate means was provided for the distribution of the liquids than square cans $4\frac{3}{4}$ x $4\frac{3}{4}$ x $2\frac{1}{2}$ inches deep, placed at regular intervals throughout the beds. Although in some previous greenhouse experiments with ordinary petrol, porous tiles standing in the vessel holding the liquid was effective in increasing the evaporation rate, its application to the seed-beds at this juncture was considered premature. The use of open cans necessitated tedious filling by hand every afternoon, immediately preceding replacement of the covers for the night. Labour-saving devices will be desirable if the general process proves applicable commercially.

On account of the abundance of downy mildew on immature plants and suckers left in the field after harvesting the crop, protection of the seedlings was begun on the 26th March, three weeks after sowing and seven days after germination. A number of cans providing for a total surface of liquid approximately equal to 1/144, 1/72, and 1/36 respectively, of the area of the seed-beds in which they were placed, had benzol added to them while the covers were on during the nights and on inclement days. The same was done for the toluol series. In two other

* Paint discolouration by fungal growth is the subject of a separate investigation.

beds, arrangements were made for evaporation from an area equal to 1/72 of the seed-bed for about four hours after the covers were put on, and for one-half that area afterwards. Two other seed-beds, each provided with an evaporating surface of benzol and toluol equal to 1/72 of the seed-bed area, were kept covered day and night. Six other seed-beds, suitably distributed, were used as controls.

During the past three years, downy mildew was perhaps more widespread and destructive than for some years previously, for, as far as we could gather, no seed-beds in the district escaped without serious loss. Furthermore, the autumn weather conditions were conducive to an epidemic on plants with unripe leaves.

Some idea of the climatic conditions prevailing during the period of the experiments may be gathered from the mean weekly maximum and minimum temperatures, and the rainfall data given in Tables II. and III.

Table II.—Mean Weekly Maximum and Minimum Temperature, Eurobin, Victoria.

Period, Week Ending.	Maximum °C.	Minimum °C.
24th March	20·3	11·3
31st March	23·3	8·3
7th April	28·1	13·1
14th April	16·2	8·7
21st April	13·5	8·0
28th April	19·2	9·0
5th May	17·0	5·8
12th May	16·4	6·5
19th May	13·6	6·4
26th May	17·2	3·7
2nd June	14·3	5·8

Table III.—Rainfall, Eurobin, Victoria.

March.		April.		May.		June.	
Date.	Points.	Date.	Points.	Date.	Points.	Date.	Points.
11th	5	8th	107	9th	23	7th	78
14th	59	9th	3	11th	30	8th	37
16th	21	12th	103	12th	20		
19th	20	13th	28	15th	30		
20th	40	14th	10	16th	17		
21st	68	16th	70	17th	20		
22nd	8	17th	5	18th	12		
24th	20	18th	20	30th	30		
		19th	52				
		20th	37				
		22nd	35				
		28th	35				
		29th	60				
Totals ..	241	..	565	..	182	..	115

Note.—100 points equal 1 inch.

The disease was abundant in neglected fields in the neighbourhood during the course of the experiment. The probability of unprotected seedlings escaping was therefore remote. Nevertheless, the seedlings in all the beds were inoculated by dusting with conidia from diseased leaves on the 3rd, 5th, and 10th May. Infection had occurred in the meantime, however, for diseased seedlings were found in one bed on the 27th April.

On the 6th June, when the seed-beds were examined by all of us, the six beds used as controls presented a striking contrast to those protected by the vapours. All the seedlings in five of the former were dead, and in the other were only a few moribund specimens covered with downy mildew.

Under the conditions of the experiment, the reduced evaporating surface in every case proved inadequate to prevent the occurrence of isolated areas of diseased plants. The latter, however, were thriving, and were, to all appearances, very little the worse for the attack. The spread to other plants was extremely slow. When the seedlings were pulled and examined on the 8th June, it was found that relatively few were diseased. The hydrocarbons, therefore, not only prevented infection when used in the correct proportions, but smaller amounts minimized the effects of the disease. It is the opinion of the writers, however, that only entire prevention of the disease will be profitable if these methods are adopted commercially.

Confirming the results of the second and third experiments, benzol again prevented the disease when the area of the liquid was 1/72 or more of the surface of the seed-bed. All the plants in the beds were healthy throughout the course of the experiment. Finally, on 8th June, every seedling was uprooted and critically examined, but, as before, no diseased specimens were found. In this experiment, toluol was not completely successful in preventing downy mildew, but the control obtained indicated that improvement in technique would have prevented the occurrence of the disease. Details of the experiment are summarized in Table IV.

4. Discussion.

As this paper is the first of a series of reports on the influence of certain hydrocarbons on downy mildew of tobacco, discussion of the relation of these compounds to the fungus and host will be reserved pending the accumulation of more detailed experimental results.

Toluol was used by Russell and Petherbridge (10, 11) toluol and benzol by Russell and Buddin (12), and benzol by Matthews (7) for sterilization of soil used in greenhouse work. Lemmerzahl (6) obtained partial control of potato wart by disinfecting the soil used in his experiments with crude benzol. Bateman (2) compared the efficacy of benzol with other substances for wood preservation. Toluol was one of several volatile compounds tried by Roberts and Dunegan (13) in experiments in the control of brown rot of stored peaches. Ezekiel and Taubenhaus (4, 5) found that, in laboratory and greenhouse experiments, xylol was effective in killing the cotton root-rot fungus, *Phymatotrichum omnivorum* (Shear) Dug. in the soil, and later, in field experiments, they obtained similar results, though the roots of the plants were injured.

TABLE IV. SUMMARY OF DATA OF EUROBIN EXPERIMENT ON THE CONTROL OF DOWNY MILDEW BY BENZOL AND TOLUOL.

Each seed-bed was 20 x 6½ *ft. The plants were inoculated with conidia on the* 3*rd*, 5*th, and* 10*th May.*

Number of Bed.	Disposition of Covers.	Fungicide.	Evaporating Surface.	Date of Occurrence of Downy Mildew.	Remarks.
1	Removed on fine days ..	Benzol	2N *	.. ..	Leaves thickened and a few crinkled; otherwise good plants, no downy mildew
2	„ „ „ ..	„	N	.. ..	Good plants. No downy mildew
3	„ „ „ ..	„	½N	9th May ..	Disease limited to shaded side of seed-bed
4	„ „ „ ..	„	N to ½N	9th May ..	Disease limited to shaded side of seed-bed
5	Always in position ..	„	N	.. ..	Good plants. No downy mildew
6	Removed on fine days ..	Toluol	2N	.. ..	Good plants. No downy mildew
7	„ „ „ ..	„	N	27th April 6th June	Two small centres of infection. No spread
8	„ „ „ ..	„	½N	9th May ..	Disease widespread but plants not killed
9	„ „ „ ..	„	N to ½N	9th May ..	Disease limited to shaded side of seed-bed
10	Always in position ..	„	N	6th June ..	Small centre of infection on shaded side
11	Removed on fine days ..	None	None	30th April ..	Plants all dead by 6th June
12	„ „ „ ..	„	„	2nd May ..	Plants all dead by 6th June
13	„ „ „ ..	„	„	3rd May ..	Plants all dead by 6th June
14	„ „ „ ..	„	„	4th May ..	Plants all dead by 6th June
15	„ „ „ ..	„	„	9th May ..	Plants all dead by 6th June
16	Always in position ..	„	„	9th May ..	A few plants survived until 6th June, even though covered with downy mildew

* ½N = $\frac{1}{144}$; N = $\frac{1}{72}$; 2N = $\frac{1}{36}$ of seed-bed area.

Hitherto, these hydrocarbons have not been applied as fungicides to growing plants. Like other compounds of that class, they have a caustic effect on foliage. Therefore, when such compounds have been used as insecticides, they have been applied in the form of dilute emulsions. In our experiments, white spots on the leaves and rotting of the roots have been observed adjacent to the containers, the leaf injury resulting directly from splashing of the liquid, the root-rotting presumably from high local concentration of vapour in the soil from an occasional overflow when filling. In the experiments at Eurobin, crinkling and thickening of the leaves, as well as slight yellowing and stunting, have been noted in the seedlings in the immediate vicinity of the cans in the beds in which double the necessary concentration of benzol vapour was used. Seedlings used in some of our laboratory work have sometimes been killed by excessive concentration of the vapour, the general appearance of the dead plants simulating that produced by the first killing frost of autumn. However, the danger of injuring seedlings in cold-frames is slight, even though the ratio of the evaporating surface to that of the bed is twice that used in our experiments. On the other hand, the concentration obtained with the normal evaporating surface of 2 sq. in. to 1 sq. foot of seed-bed has been repeatedly shown to be sufficient to prevent the spread of the disease to healthy seedlings, even though diseased specimens were transplanted amongst them. We may therefore expect that, in certain districts, smaller amounts may be sufficient to protect the plants adequately. However, this can be determined only by experiments in those districts in spring. The amount vaporized daily depends on several factors, among which are the location, aspect, type, and construction of the seed-beds, the temperature, prevailing winds, and the level of the liquid in the containers.

According to our data, the total cost of producing transplantable seedlings will be significantly less than the usual charge of £1 per thousand made by nurserymen. The comparatively high cost of growing seedlings under the conditions described, demands in return for the expenditure the assurance of the maximum number of healthy transplants that the seed-bed will allow. It is therefore necessary that other causes of loss of seedlings, such as the damage due to the leaf miner *Phthorimaea operculella* Z. and damping-off by *Rhizoctonia* and *Pythium* sp., etc., be reduced to the minimum.

Although the hydrocarbons used in our experiments are of low boiling points and therefore evaporate at ordinary out-door temperature at rates sufficient to prevent or control the disease, the possibilities of others that require a moderate amount of heat for volatilization will not be disregarded.

These results were obtained within a slightly greater range of temperature than that which normally prevails during spring in the tobacco districts of New South Wales and Victoria. The necessary or desirable modifications of the materials and methods for commercial use in those districts may therefore be expected to be fewer, and of lesser degree, than those necessary in warmer climates, such as prevail in the northern districts of Queensland.

It may be well to add that benzol, toluol, and xylol, like motor spirit, are highly inflammable, and form explosive mixtures with air. Consequently, striking matches or smoking in the immediate vicinity

of beds should be strictly avoided. Apart from the fire hazard, the use of these hydrocarbons as described in this paper is not, as far as we know, attended with danger or injury to health. In confined situations, however, when high concentrations of the vapour are inhaled for some time, undesirable effects may follow.

5. Acknowledgments.

We are pleased to acknowledge, with thanks, the co-operation of Messrs. Panlook Bros. Pty. Ltd., of Eurobin, Victoria, in kindly allowing us the use of their seed-beds, and for their help and unfailing courtesy during the progress of the experiments made there. We are also much indebted to the Australian Gaslight Co., of Sydney, for their courtesy in supplying us with enough benzol, toluol, and naphtha for our first and second out-door experiments.

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The Unreliability of Selection in the F_2 for Breeding Wheat Resistant to Flag Smut.*

By J. R. A. McMillan, M.S.†

Summary and Conclusions.

1. Sixteen crosses between varieties of wheat with different degrees of resistance or susceptibility to flag smut have been carried through the F_4.

2. There was a high correlation between the amount of disease in an F_2 population, and the average of the corresponding F_3 families for the sixteen crosses, but there was practically no correlation between the condition (healthy or diseased) of an F_2 plant and the amount of disease in the corresponding F_3 progeny. A careful analysis of the data of the 1390 F_3 families did show that there was a significant difference between the amount of disease from healthy and from diseased F_2 plants, but such difference was small and not worth considering for breeding purposes. For practical purposes, it can be regarded that diseased F_2 plants produced just as resistant F_3 lines as did healthy ones.

3. There was a high correlation between the amount of disease in an F_3 family and that in the corresponding F_4 progenies.

4. For breeding flag smut resistant varieties, an individual plant test, as for example in the F_2, for reaction to this disease is useless, and selection should be based on progeny tests beginning with the F_3.

5. If the F_2 population is small, a flag smut test on it may be definitely harmful, as it reduces the amount of material from which to select for other characteristics.

Experiments have been conducted at Canberra over a period of years to determine the mode of inheritance of reaction to the disease known as flag smut of wheat. During the course of these investigations, much valuable information has been obtained, but it is intended to report in this paper only on the basis of selection to be used in breeding flag smut resistant varieties.

Crosses were made between varieties of different degrees of susceptibility or resistance in various combinations. Not only were resistant and susceptible varieties crossed, but crosses were also made between varieties which are susceptible and between those which are resistant.

An F_1 was raised under conditions free from flag smut, which thus enabled healthy plants to grow and produce a large number of seeds.

For the F_2 generation, up to 500 seeds were sown of each cross which was carried on. These were sown in rows two links apart with the seeds spaced at half-link intervals in the row. The inoculation was carried out by the following method. The spores were pre-soaked on the surface of distilled water for 2 to 3 days under laboratory conditions. The seeds were also soaked in distilled water for 10 to 12 hours, when they were removed to a dish containing pre-soaked spores, taken to the field, and sown. Seeds, removed from the dish with forceps, thus covering them with a film of pre-soaked spores, were sown without delay. The material was sown on 4th May, 1931, and brairded on 11th-12th May.

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* Caused by *Urocystis tritici* Koern.

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Late in the season, each plant was labelled with a small merchandise tag on which was recorded its pedigree number. The material was examined for flag smut and the condition of each plant, whether healthy, "partially" or "totally" diseased, was recorded in the field book. The F_2 data have been tabulated and are presented in Table 1.

TABLE I.—F_2. RESULTS OF F_2 FIELD TESTS AT CANBERRA, 1931.

Pedigree Number.	Parents of Cross.	Number of Plants.	Percentage of Plants.		
			Healthy.	Diseased.	
				"Partially."*	"Totally."*
Wx 23A	Canberra x Bunyip	421	58	34	8
,, 42A	Canberra x Geeralying ..	360	35	27	38
,, 53A	Canberra x Nabawa ..	365	27	49	24
,, 41A	Canberra x Federation ..	241	8	19	73
,, 52B	Canberra x Minister ..	208	25	21	54
,, 60A	Canberra x Red Rock ..	377	35	33	32
,, 152A	Federation x Sunset ..	365	62	22	16
,, 343A	Federation x Sultan ..	302	23	27	50
,, 71A	Minister x Cedar	149	30	22	48
,, 225A	Minister x Sultan	408	28	37	35
,, 29A	Red Rock x Bunyip ..	450	65	32	3
,, 167A	Red Rock x Geeralying ..	391	77	22	1
,, 228A	Red Rock x Nabawa ..	409	57	29	14
,, 22A	Sultan x Bomen	282	26	28	46
,, 275A	Cadia x Galgalos	92	56	17	27
,, 31A	Cadia x Geeralying	423	62	30	8
,, 3A	Aussie x Florence	260	34	50	16
,, 8B	Bena x Bunyip	270	65	27	8
,, 24A	Cleveland x Bunyip ..	417	64	32	4
,, 27A	Gresley x Bunyip	455	65	34	1
,, 158A	Hard Federation x Firbank ..	415	34	37	29
,, 159A	Yandilla King x Firbank ..	156	17	36	47
,, 298A	Bunyip x Galgalos	364	54	30	16
,, 25A	Bunyip x Geeralying ..	425	78	21	1
,, 162A	Nabawa x Galgalos	368	45	38	17
,, 28A	Nabawa x Bunyip	428	76	23	1
,, 165A	Nabawa x Geeralying ..	383	73	23	4
,, 161A	Galgalos x Geeralying ..	420	89	9	2

* "Partially" or "totally" diseased means that some or all, respectively, of the tillers of plant were diseased.

When mature, all plants were harvested by pulling out and were stored until the following season. For the F_3, only 16 crosses were carried on, available labour limiting the number. In this generation, 39 families were raised from the cross Cadia-Galgalos, 47 from Firbank X Yandilla King, 69 from Bomen X Sultan, and 87 to 100 from the remaining 13. Of those families raised, some were from healthy and some from diseased F_2 plants. The healthy and diseased F_2 plants used for the F_3 were taken at random from their respective groups. In order that the F_3 test should be efficient, it was arranged that each cross should be tested separately. Each test was arranged in four randomized blocks, in which each block had 105 rows, 2 links apart, 12½ links long. This allowed for 100 F_3 families, the two parents of the cross and three varieties, Canberra, Nabawa, and Waratah, which were grown in all

blocks in the field to serve as checks. Seeds were sown at half-link intervals in the row, thus allowing for 25 seeds per row and 100 for the family in the four blocks.

The method of inoculation was changed from that used in the F_2, as it had been shown that pre-soaking was unnecessary. The seed (dry) of an F_3 family was placed in a petri dish together with a little dry inoculum (sieved spores). Water was atomised on these, and the whole mixed so that each seed was practically covered with a coating of black spores. The seed was taken to the field and sown within an hour or two. The work was arranged so that all the seeding of a cross was performed on one day, the seeding being done during the period 11th April, 1932, to 22nd April, 1932. Later in the season, a count of the healthy and diseased plants of each row was made. A summary of the data so obtained is presented in Table 2. When mature, some of the rows were harvested as before.

An F_4 generation of the three crosses, Canberra-Geeralying, Canberra-Nabawa, and Nabawa-Geeralying, was raised in 1933. The procedure was similar to that used for the F_3 in 1932, but only 20 F_4 families were raised from any one F_3 and the varieties grown in every block throughout the field for check purposes were Canberra, Geeralying and Nabawa. A summary of the data obtained from the F_4 is presented in Table 4.

Discussion of Results.

As mentioned previously, it is intended to report only on one aspect of the results in this paper, as others will be dealt with later. In Table 2, it will be seen that there is a correlation between the average F_2 result and that of the F_3, and that where the percentage of disease in F_2 was low or high, that in the F_3 was also low or high respectively.

The F_3 families for each cross have been classified into groups according to the amount of disease, and such classes have been divided into two groups according to the condition—healthy or diseased—of the parent F_2 plant. It will be noted that there is no appreciable difference between the distribution of the F_3 families derived from healthy and those derived from diseased plants. Diseased F_2 plants produced just as resistant F_3 lines as did healthy ones. Biometrical tests were applied to be certain of this.

For each cross, the average amount of disease in all F_3 families from healthy and from diseased F_2 plants is shown separately in the last row of Table 2. The diseased F_2 plants gave on the average 3.5 per cent. more disease in the F_3 than did the healthy F_2. Using Yates'* test for a 2 x S classification with uneven numbers in the classes, it was found that the difference was significant, P being less than 0.01. The difference, however, is very small, especially when compared with the difference between a resistant variety, e.g., Geeralying with 1 to 5 per cent. and a susceptible variety, e.g., Canberra with 80 to 90 per cent.

An examination of Table 1 will show that in some crosses there was a considerable proportion of F_2 plants classified as "totally" diseased. Such plants seldom produced seed, and therefore could not be grown on into F_3. Hence, except in nine cases (shown in Table 2), the diseased

* Yates, F. The analysis of multiple classifications with unequal numbers in different classes. *Journ. Amer. Statistical Society*, 1934: 51-66.

Table 2.—F_3. Distribution of F_3 Families Derived from Healthy and from Diseased F_2 Plants.

—	Cross.																					
	Wx 161A, Galgalos x Geeralying.		Wx 25A, Bunyip x Geeralying.		Wx 167A, Geeralying x Red Rock.		Wx 28A, Bunyip x Nabawa.		Wx 165, Geeralying x Nabawa.		Wx 29A, Bunyip x Red Rock.		Wx 31A, Cadia x Geeralying.		Wx 23A, Bunyip x Canberra.		Wx 228A, Nabawa x Red Rock.		Wx 275A, Cadia x Galgalos.		Wx 298A, Bunyip x Galgalos.		Wx 162A, Galgalos x Nabawa.		Wx 42A, Canberra x Geeralying.		Wx 53A, Canberra x Nabawa.		Wx 22A, Bomen x Sultan.		Wx 159A, Firbank x Yandilla King.	
F_2 percentage disease ..	11		22		23		24		27		35		38		42		43		44		46		55		65		73		74		83	
Parents of F_3	H 87	D 12	H 82	D 16	H 85	D 14	H 74	D 25	H 73	D 27	H 57	D 30	H 68	D 28	H 63	D 32	H 69	D 29	H 29	D 10	H 60	D 30	H 61	D 34	H 42	D 42	H 38	D 57	H 28	D 41	H 16	D 31
F_3 percentage disease—																																
0– 10	70 :	7	67 :	10	53 :	2	62 :	22	47 :	17	4 :	4	6 :	4	1 :	–	6 :	1	5 :	–	8 :	4	35 :	17	2 :	–	– :	–	..		1 :	–
11– 20	14 :	1	13 :	5	26 :	7	12 :	3	18 :	9	18 :	10	15 :	6	13 :	4	17 :	5 (1)	8 :	1	24 :	8	13 :	8 (1)	2 :	1	3 :	1	..		– :	1
21– 30	3 :	2	1 :	1	4 :	5	..		4 :	1	21 :	7	15 :	8	14 :	5 (1)	26 :	14	4 :	2	11 :	11	8 :	1	4 :	2	5 :	4	3 :	1	3 :	2
31– 40	– :	2	1 :	–	1 :	–	..		2 :	–	10 :	7	12 :	5	16 :	10	12 :	7	3 :	2	15 :	5	5 :	5	9 :	9 (2)	7 :	6 (1)	4 :	3	– :	7
41– 50	..		..		1 :	–	..		1 :	–	3 :	1	13 :	1	12 :	6	8 :	2	3 :	2	2 :	1	– :	2	7 :	13	6 :	13	6 :	6 (1)	2 :	5
51– 60	..		..		..		..		– :	–	– :	1	6 :	3	4 :	3	..		4 :	2	– :	1	– :	1	10 :	11	8 :	9	2 :	12 (1)	6 :	9
61– 70	..		..		..		..		1 :	–	1 :	–	1 :	1	2 :	3	..		1 :	–	..		..		5 :	3	8 :	10	5 :	9	4 :	6
71– 80	..		..		..		..		..		..		..		1 :	1	..		– :	1	..		..		3 :	3	1 :	11 (1)	4 :	6	– :	1
81– 90	..		..		..		..		..		..		..		..		..		1 :	–	..		..		– :	–	– :	2	1 :	4	..	
91–100	..		..		..		..		..		..		..		..		..		..		..		..		– :	–	– :	1	3 :	–	..	
Percentage disease in F_3 from healthy and from diseased F_2 plants ..	6	14	7	8	10	17	5	7	11	8	25	24	30	27	33	39	25	27	29	41	21	23	11	16	45	48	45	55	57	60	48	49

The numbers in "( )" indicate the number of F_3 plants of this group which were "totally" diseased.

The table can be read as follows:—Cross No. Wx 161A, Galgalos x Geeralying, gave 11 per cent. of diseased plants in the F_2. Of the healthy plants 87 were used as parents for the F_3, and of these F_3, 70 gave 0–10, 14 gave 11–20, and 3 gave 21–30 per cent. of disease—the average being 6 per cent. Of the diseased F_2 12 were used as F_3 parents, and of the F_3 7 gave 0–10, 1 gave 11–20, &c., per cent. of disease in the F_3—the average being 14 per cent.

F_2 plants grown on were taken from the "partially" diseased class. Therefore, a criticism may be levelled at the conclusions drawn from the results because the F_3 was not drawn from a random sample of the F_2.

It will be noted, however, that the nine "totally" diseased F_2 plants which were carried on produced families with different percentages of disease in the F_3—perhaps a little more towards the healthy than to the disease end of the scale.

The best method, of course, of determining whether or not there is any bias would be to compare under similar conditions two sets of F_3 families, one of which would be derived from surviving F_2 plants raised under flag smut conditions, and another from an F_2 raised under flag smut free conditions. Unfortunately, data from such an experiment are not available at present, but there is some evidence from another F_3 test which is pertinent. For another reason, an F_2 of the cross Canberra-Geeralying had been raised under healthy conditions, and a sample of this was used for an F_3 flag smut test. The distribution of the families according to the amount of disease is shown in Table 3.

TABLE 3.—F_3. DISTRIBUTION FROM TWO F_2 SAMPLES.

Cross Canberra x Geeralying.

Percentage of Disease in F_3.	F_2 Subjected to Disease. (F_3 in Field, 1932.)	F_2 not Subjected to Disease. (F_3 in Greenhouse, 1934.)
0– 10	2	1
11– 20	3	–
21– 30	6	2
31– 40	18	5
41– 50	20	6
51– 60	21	15
61– 70	8	23
71– 80	6	19
81– 90	–	22
91–100	–	7
Total	84	100
Average percentage of disease—		
In F_3	47	68
In Canberra	81	93
In Geeralying	1	17

In the same table, is given the distribution for the F_3 derived from an F_2 of the same cross raised under flag smut conditions (actually data from Table 2). In this F_2 test (the one raised under flag smut conditions), 38 per cent. of the plants were "totally" diseased and only two were carried on into F_3. If, therefore, the breeding behaviour of the "totally" diseased plants differs from that of the "partially" diseased and healthy ones, it would be expected that the samples of F_2 from which the "totally" diseased had been excluded, would produce more resistant types in F_3 than would the random sample of F_2 (raised under flag smut free conditions). It is obvious from Table 3 that there is a significant difference between the two sets of data, but the important point to consider is the amount of this difference that is due to genotype.

A comparison of the results of the check varieties will show that Canberra increased from 81 to 93 per cent. and Geeralying from 1 to 17 per cent. from one set of conditions to the other. Unfortunately, it is not known how other varieties of genotypes would respond to the different conditions, and therefore a reliable estimate of the behaviour of one sample under the other set of conditions cannot be made. Assuming that there is no interaction between genotype and these conditions with respect to percentage of disease, it might have been expected that the sample grown in the field would have given 14 per cent. (average of differences of checks) more disease if it had been grown under the conditions of the other sample. The difference in the average of the two samples being 21 per cent., there still remains 7 per cent. to be accounted for. Such might easily be due to experimental error, but if not, then the genotypic differences between the samples is very small. It is evident, therefore, that the rejection of "totally" diseased F_2 plants has very little, if any, effect on the F_3 results.

From this analysis then, it can be concluded that the correlation between the condition (healthy or diseased) of an F_2 plant and the amount of disease in the corresponding F_3 progeny is very small. Further, from the point of view of breeding flag smut resistant varieties, it is obvious that selection in the F_2 for this characteristic is useless, and likewise any test for reaction to flag smut in the F_2 is also useless. In some cases in which the population is small, it may be definitely harmful, since the F_2 population from which selections for F_3 are made is still further reduced by the rejection of diseased plants.

Since selection for flag smut resistance in F_2 is worthless, the question arises as to how selection for this characteristic should be made.

An examination of the F_4 results presented in Table 4 shows that there is a high correlation between the percentage of disease in the F_3 and that in the F_4 progenies derived from such F_3. Therefore, for selection of types resistant to flag smut, selection on the basis of the F_3 results is satisfactory. Such of course really amounts to a selection of F_2, but this selection is based on the progeny test of such F_2 and not on the individual F_2 results. Thus, for the breeding of flag smut resistant varieties, the first selection should be based on the F_3 results—the more healthy of the F_3 lines being continued.

Since an F_2 test for reaction to flag smut is useless for breeding purposes, some consideration might be given to the reason of this. Three separate possibilities—and of course combinations of these—present themselves. First, the effect of environment may be sufficient to mask that of the genotype, but this is hardly likely to be the case, because, even if environment were the main cause, some correlation would be expected between the individual result and that of its progeny. The second possibility is that the reaction of the F_2 plant depends primarily upon its genotype, but the inheritance is complicated and due to a large number of genes which would present many types of breeding behaviour from one phenotype. Thirdly, the result may be due to predetermination*. Predetermining influences have been shown to cause variation in yield in a pure line and they may be operating here with respect to reaction to flag smut. In this case, as there is practically

(*) McMillan, J. R. A.—Predetermination as an influence on yield in wheat plants. This *Journal*, 8: 1, 1935.

TABLE 4.—F_4. DISTRIBUTION OF F_4 PROGENIES DERIVED FROM F_3 WITH DIFFERENT AMOUNTS OF DISEASE.

(The percentage of disease in the F_3 is shown at the top of a column and the distribution for the corresponding F_4 immediately below.)

Canberra x Geeralying.

Percentage of disease in F_3 =	5	9	13	14	14	22	25	27	28	29	63	65	65	66	71	71	73	73	74	75	75
F_4—																					
0– 10	5	..	..	..	..	3	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..
11– 20	12	4	..	2	1	9	1	4	2	1	..	..	..	1	..	..	..	..	..	..	..
21– 30	1	11	3	4	6	8	4	2	4	8	3	1	..	..	..	..	..	..	..	..	..
31– 40	2	5	6	4	8	..	7	8	6	5	4	1	..	..	..	1	..	..	..	..	..
41– 50	..	..	8	8	3	..	6	4	3	4	1	..	1	1	..	5	..	1	..	..	2
51– 60	..	..	3	2	1	..	2	1	3	1	4	4	2	2	..	7	2	3	1	..	5
61– 70	..	..	..	..	1	..	..	..	1	..	3	5	3	8	..	6	2	6	1	4	8
71 –80	..	..	..	..	..	..	..	..	1	..	3	7	8	6	6	1	8	9	7	6	5
81 –90	..	..	..	..	..	..	..	..	..	..	2	2	5	2	11	..	6	1	10	10	..
91–100	..	..	..	..	..	..	..	..	..	..	..	..	1	..	3	..	2	..	1	..	..
Average percentage disease in F_4 =	17	25	42	38	36	18	37	32	40	32	55	65	75	65	84	55	77	68	80	79	64
Canberra	80	79	85	83	79	69	71	71	84	56	83	15	95	97	94	70	84	75	87	84	77
Geeralying	15	3	11	18	6	6	12	13	9	3	5	80	11	30	9	11	11	7	15	12	10
Nabawa	7	5	21	20	12	5	7	6	14	8	12	9	7	9	24	13	31	4	9	11	10

Canberra x Nabawa.

Percentage of disease in F_3 =	12	16	19	19	24	24	24	26	28	28	28	29	72	72	73	73	75	75	75	77	77	82	83	92
F_4—																								
0– 10	8	9	1	..	4	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
11– 20	7	7	8	1	2	1	1	1	2	6	1	3	..	..	..	..	..	..	1	..	..	..	..	..
21– 30	5	2	8	8	7	1	7	2	8	5	3	5	..	..	..	..	..	..	2	2	..	..	..	1
31– 40	..	2	1	7	5	4	10	4	4	6	6	7	1	..	2	3	..	1	4	2	..	..	1	..
41– 50	..	..	1	4	1	5	2	5	5	3	5	3	2	..	1	7	1	1	5	4	..	..	1	..
51– 60	..	..	1	..	1	6	..	5	1	..	3	2	3	1	2	5	4	8	5	3	1	2	5	1
61– 70	..	..	..	..	..	3	..	2	..	..	1	..	9	3	7	5	3	4	2	6	7	5	4	1
71– 80	..	..	..	..	..	..	..	..	..	..	..	..	4	5	4	..	5	5	1	3	5	7	6	10
81– 90	..	..	..	..	..	..	..	..	..	..	..	..	1	8	4	..	7	1	..	..	5	5	3	6
91–100	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	2	1	..	1
Average percentage of disease in— F_4 =	19	14	25	32	26	47	33	41	33	28	37	33	63	80	66	52	72	62	46	55	75	75	67	75
Canberra	87	87	94	98	81	95	85	84	73	61	78	74	91	91	85	96	93	88	88	88	84	89	89	94
Geeralying	2	3	9	5	0	1	11	5	5	5	9	3	5	0	2	3	7	5	4	3	25	4	6	0
Nabawa	21	4	11	11	13	13	12	11	12	14	24	27	15	9	12	12	19	..	18	4	24	18	13	9

TABLE 4.—*continued.*

Nabawa x Geeralying.

Percentage of disease in F_3 =					0	0	0	0	1	1	1	2	2	3	3	3	4	4	4	4	7	9	26	26	28	30	33	44	70
F_4—																													
0– 10	..	..	..	..	16	11	9	19	19	16	18	15	20	6	6	13	7	2	13	11	13	20	1	1	1	5	1	..	1
11– 20	..	..	..	..	4	9	9	..	1	3	2	4	..	9	7	6	5	10	5	8	5	..	..	3	6	11	5	..	..
21– 30	..	..	..	..	..	..	2	1	..	1	..	1	..	3	4	1	7	4	..	1	2	..	6	8	7	4	8	1	..
31– 40	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	..	1	4	..	..	..	..	5	7	4	..	3	2	..
41– 50	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	3	1	2	..	2	5	3
51– 60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	2	..	..	..	1	4	7
61– 70	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	2	..	..	..	..	3	8
71– 80	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	4	1
81– 90	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..
91–100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Average percentage disease in— F_4 =	..	..	..	..	9	10	12	4	6	7	5	8	3	15	18	8	16	21	13	11	10	2	39	27	25	17	27	55	57
Canberra	..	..	..	..	82	85	95	82	86	81	87	77	88	90	81	97	97	91	83	91	87	85	91	77	100	61	85	91	75
Geeralying	..	..	..	..	..	9	6	5	3	4	2	3	0	0	6	9	5	7	11	0	3	6	4	16	2	5	5	7	..
Nabawa	..	..	..	..	10	8	17	2	6	16	4	7	3	29	8	22	23	16	13	6	2	13	20	5	24	13	15	12	9

no correlation between the condition of an F_2 plant and its progeny, it would appear that the condition which governs the F_2 plant reaction is the same in all F_2 individuals. If such is the case, this condition would have been determined probably by the female parent of the F_2 plants, and it may be a case of delayed gene action—a DZ type according to Haldane*.

Experiments are in progress to obtain more information as to the cause of the behaviour reported.

Acknowledgments.

The author wishes to acknowledge his indebtedness to Phyllis Jarrett (Mrs. A. J. Nicholson) for inoculating and arranging for counts of disease in the F_2 and F_3 material; to Miss F. E. Allan, Biometrician, for help in connexion with the field arrangement of the F_3 and F_4 tests and the application of Yates' test; and to officers of the Section of Genetics for suggestions in the preparation of the manuscript.

(*) Haldane, J. B. S.—The time of action of genes, and its bearing on some evolutionary problems. *Amer. Nat.* 66: 5-24, 1932

Apple Investigations in Tasmania : Miscellaneous Notes.*

6. Bruising and Breakdown in Jonathan Apples.

By W. M. Carne.†

It is well known that bruises render apples less attractive to the purchaser, that they are a cause of waste to the consumer, and that they increase the liability of the fruit to become rotted by fungi. It is not generally recognized that, in some varieties at least, bruises may be responsible for the onset of breakdown or internal browning (this *Journal*, **3**: 181, 1930).

The relation of bruising to breakdown in Jonathan apples has been emphasized in a recent report by Messrs. N. E. Holmes, C. R. Furlong, and J. Barker on behalf of the Food Investigation Board of Great Britain. This report was the result of the examination in London of 40 boxes of Victorian Jonathans in 1934 as part of consignments shipped by two growers. Examination of the fruit was commenced three days after discharge. At the same time, it was divided into not bruised, slightly bruised, and commercially bruised fruit as shown in Table 1.

Table 1.—Number of Bruised Fruits.

Grower.	Slightly Bruised.	Commercially Bruised.	Not Bruised.
A	51	18	31
B	52	25	23

At that time the wastage in both lots did not amount to 4 per cent. Three weeks after the date of discharge, a second examination was commenced with the wastage results shown in Table 2.

Table 2.—Percentage Wastage in 40 Boxes Victorian Jonathans.

Grower.	Number of Boxes.	Examination.	Rotted.	Breakdown.	Total Waste.
			%	%	%
A	18	1st	0	3	3
		2nd	4	20	24
B	22	1st	2	2	4
		2nd.	8	9	17

When first examined, the fruit was well coloured and fairly ripe, that from grower B being the better flavoured and the more crisp. At the second examination, both lots were becoming over-ripe and losing flavour. As, on the average, Australian apples take about three weeks after unloading to reach the English consumer, the results of the second examination are of importance. More than one-half the wastage was

* Continued from page 78 of the May, 1935, issue of this *Journal*.

† An officer of the Division of Plant Industry, C.S.I.R., who is accommodated at the University of Tasmania, Hobart.

breakdown and more than twice as much of this occurred in the fruit from grower A than in that from grower B. In the same lot, the larger sizes developed more breakdown and rots than the smaller. The report states "in apples showing early stages of breakdown it was obvious that in almost every instance the disease commenced at a bruise." Both breakdown and rotting increased with the severity of the bruising (Table 3). The report continues "observations indicate that bruising was the main causal factor in determining the development of breakdown and that the wastage from breakdown would have been very small in amount if the fruit had not been bruised."

Table 3.—Breakdown and Rots at 2nd Examination in Relation to Bruising at 1st Examination.

Grower.	Breakdown as Percentage of Fruit Classified as—		
	Sound.	Slightly Bruised.	Commercially Bruised.
	%	%	%
A	4	18	59
B	1	4	26

Grower.	Rots as Percentage of Fruit Classified as—	
	Sound.	Bruised.
	%	%
A	1	3
B	3	5

It is evident that the fruit from grower A was more subject to breakdown than that from grower B, as the bruising was practically the same in the two lots. The difference may have been a matter of difference in maturity. The examination did not show a consistently greater amount of bruising in the larger than the smaller sizes of fruit. The report states that the importance of bruising was so marked in relation to the fruit examined as to indicate the desirability of determining whether the association of bruising and breakdown is normal in Victorian Jonathans.

It has been the writer's experience in Western Australia and in Tasmania that bruising is always a potential stimulus to breakdown in the Jonathan, but that, in general, it is one of the least important causes in local cool-stored fruit. This appears to be due to two reasons. Firstly, fruit is rarely badly bruised when taken from cool store or in experimental lots. Secondly, breakdown following bruising is relatively slow in its onset, and, if present, is often masked by the more rapidly developing types of breakdown. In 1934 and 1935, years in which other breakdowns were comparatively rare in southern Tasmanian Jonathans, breakdown in experimental lots was practically confined to bruised fruit during, and after, cool storage for periods up to eighteen weeks.

The Mechanics of Securing Even Distributions of Bacteria on Agar Surfaces.

*By A. R. Riddle, A.B., M.Sc.**

In an earlier issue of this *Journal* (5: 133, 1932), an outline was given of the arrangements made by the Queensland Meat Industry Board in providing laboratory and other facilities for the Council's Section of Food Preservation and Transport in connexion with the Section's programme of investigation on the storage and preservation of meat. In addition, the Board has recently made further funds available to meet the cost involved (salary, equipment, &c.) in the appointment of an investigator (Mr. A. R. Riddle) to concentrate on a study of the treatment of meat with X-rays and other radiations of different frequencies to ascertain if any bacterial or fungal contamination could be controlled in such a way. The work discussed in the article that follows forms a part of Mr. Riddle's programme.—Ed.

Summary.

After reviewing various means used for securing even distributions of bacteria on agar surfaces, a method which employs a spray gun operating on a compressed air line is described. The Petri dish is rotated in a vertical plane, while being sprayed. The four counts of colonies in quadrant areas differ from each other on the average by slightly less than 1 per cent., the difference seldom exceeding 2 per cent.

1. Introduction.

In order to satisfy the demands made by certain biophysical investigations, which are being conducted in this laboratory, a bacterial distribution as nearly uniform as possible, on poured agar plates, was essential. Various methods have been employed by bacteriologists and others to obtain this end. The chief of these may be summarized as:—

(i) Spreading.
(ii) Pouring and subsequent drainage.
(iii) Spraying.

(i) *Spreading.*

In 1933, Thompson(1) published an account of "a device to facilitate and accelerate the uniform distribution of inoculum over the surface of poured plates." This consisted of a slowly rotating turntable on which the plate was placed. A drop of inoculum was deposited from a pipette on the surface of the medium and spread by the combined action of the rotating turntable and a glass rod which was held on the plate in a fixed radial position.

A similar device was built here, using the gearing of a cream separator with the drive reversed. This gearing-down reduced the motor speed of 1,480 r.p.m. to approximately 14 r.p.m. Extensive tests with this method, however, failed to give the evenness of distribution needed. Occasional plates were fairly satisfactory, but the secret of reproducibility could not be found. The method would seem to be quite useful where the demand for evenness is not so rigid.

(ii) *Pouring and Subsequent Drainage.*

This method was employed by Gates (2) in some rather accurate work done at the Rockefeller Institute, using *Staphylococcus aureus*. A suspension of an 18-hour culture was washed over the agar surface,

* An officer of the Council's Section of Food Preservation and Transport who is located at the Section's laboratories in the Cannon Hill Abattoir of the Queensland Meat Industry Board.

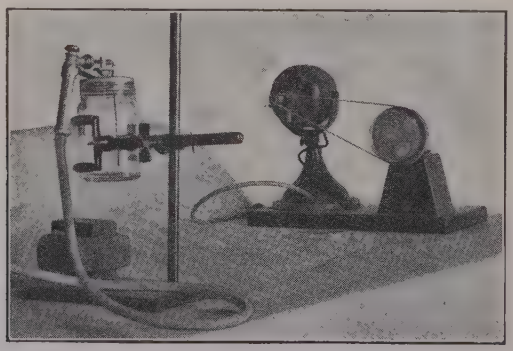
the excess drained off, and the plate allowed to stand in a vertical position until excess fluid on the surface had evaporated. Wyckoff and Rivers (3) also used this method in a modified form. Experimentation along these lines, varying both the time during which the inoculum was in the dish and the time for drainage, gave distributions where the colonies were fewer on that part of the plate which had been at the top during drainage, and greater at the bottom. Distribution across the plate, at any one level, however, appeared rather uniform. Counts made of the semi-circular areas on either side of a line from top to bottom of the plate—top and bottom being taken in reference to the drainage position—gave results which checked within 8 per cent. on plates carrying 1,500 to 2,000 colonies.

(iii) *Spraying.*

Coblentz and Fulton (4), working with *Bacterium coli communis*, atomized the suspension "as uniformly as possible over the surface of a Petri dish containing hardened sterile beef-peptone agar. . . . It was found advantageous to direct the nozzle of the atomizer upward, and to hold the Petri dish in an inverted position some 30 cm. away so as to avoid large droplets."

2. Method Employed.

Tests of this method with a De Vilbiss spray gave unsatisfactory results. A spray gun, of the household type, used for spraying insecticides, &c., produced much better distributions. Continuation of this line of attack ultimately led to the following method, which has now become routine practice. The well-shaken, saline suspension of the organism is placed in the glass container of a "Rega" spray gun. This latter is connected through a pressure reduction valve to a compressed air line and operated at 20 lb. per square inch. The spray is directed horizontally through a tunnel, at the plate, the distance from nozzle to agar being 1 metre. The Petri dish is mounted, by the aid of plasticene, on a vertical face plate, which is rotated at approximately 250 r.p.m. This rotation of the plate was found to give a more even



distribution of the organisms than that obtained when the plate was held in a fixed position. The exposure time used is 5 seconds, but this is obviously dependent on such factors as concentration of the organisms in the suspension, air pressure, distance from spray nozzle to plate, and the adjustment of the spray as to distance from, and relative heights of,

air and fluid nozzles. Two important points in adjustment are:—(i) the prevention of large drops reaching the agar surface, (ii) the limitation of the total amount of moisture received by the plate, too much fluid often leading to slime development as opposed to separate countable colonies.

The illustration will indicate the nature of the apparatus, as it appears with the tunnel removed.

3. Results of Counts of Colonies.

The 10 cm. Petri dishes used have been divided into quadrants by lines etched on the bottoms of the dishes holding the agar. Counts are made of quadrant areas of 3.5 cm. radius, within the divided quadrants of the dish.

With a total number of colonies on a plate of 500 to 1,000 the counts in four quadrants check between themselves to a little better, on the average, than 1 per cent., individual plate counts seldom exceeding 2 per cent.

As typifying the results obtained, the following figures are given of colony counts for three dilutions of a culture of the particular strain of *Achromobacter* used.

Counts in the Four Quadrants.				Maximum Difference Expressed as Percentage of Highest Count.
				%
588	582	584	586	1·02
633	637	640	636	1·09
192	191	192	191	0·52
192	193	191	193	1·04
209	211	210	209	0·95
177	177	178	178	0·56
205	204	205	203	0·97
111	112	111	112	0.89
118	117	117	117	0·85
118	117	117	118	0·85
90	90	90	90	0·00
78*	80	80	80	2·50

* It would appear desirable that conditions should be so adjusted that each quadrant might have a count of from 150 to 300 colonies. This example serves to illustrate the point that where the count in each quadrant is small, a slight variation in quadrant counts makes a large percentage difference.

The amount of protection employed when this method is utilized would be dictated by several factors, but principally the nature of the organism used. Where necessary, the whole apparatus, with the exception of the motor, could be mounted in a closed tunnel, the interior of which could be sterilized with live steam after each time of using.

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Tests on Small Clear Specimens of Green Karri (*Eucalyptus diversicolor*).

*By Ian Langlands, B.E.E.**

1. Introduction.

At the request of the Western Australian Forests Department, the Division of Forest Products is carrying out an extensive series of tests on the mechanical and physical properties of karri (*E. diversicolor*). This species grows in the south-western corner of Western Australia, and is one of the most important of the eucalypts, being available in large quantities for domestic use and export.

The main purpose of these tests was to study the method of variation in the mechanical properties with a view to devising methods by which the best quality timber can be selected for purposes, such as for cross arms and tool handles, where strength is of primary importance. Advantage was taken of the opportunity to carry out a complete series of tests according to the standards adopted in English-speaking countries(1), thus enabling the properties of the timber to be compared directly with those carried out by overseas laboratories.

Half of the material available was tested in the green condition, the other half being stacked for air-drying. The material set aside for air-drying has not yet dried down to the standard moisture content of 12 per cent., but the tests on the green material have been completed. A comprehensive report on the tests will be published when the tests on the dry material have been carried out and analyzed, but, in the meantime, it is considered advisable to give a brief summary of the results of the tests on the green condition in order that they may be available to the industry as soon as possible.

Five trees were selected by an officer of the Western Australian Forests Department as being representative of the species. From three of the trees, specimens were taken from different heights in the tree to enable the variation in properties with height in the tree to be studied.

With the exception of the toughness tests, which were carried out on specimens $\frac{5}{8}$ inch square and 10 inches long in a Denison Toughness Tester, and the shrinkage specimens, which were 1 inch square and 4 inches long, all specimens were 2 inches square, and were tested according to B.S.I. standards (2). All specimens were free from defects likely to affect the strength.

* Timber Testing Officer, Division of Forest Products, C.S.I.R.

2. Results of Tests.

The average results are as shown in Table I.:—

TABLE I.—AVERAGE MECHANICAL AND PHYSICAL PROPERTIES OF SMALL CLEAR SPECIMENS OF GREEN KARRI.

Moisture Content	per cent.	64
Nominal Specific Gravity (weight oven-dry, volume at test)		0·69
Weight per Cubic Foot (as tested)	lb.	71
Shrinkage—		
Green to 12 per cent. M.C.—		
Radial	per cent.	4·8
Tangential	per cent.	9·5
Volumetric	per cent,	13·9
Green to oven dry—		
Radial	per cent.	7·9
Tangential	per cent.	13·5
Volumetric	per cent.	20·3
Static Bending—		
Fibre stress at limit of proportionality	lb./sq. in.	7,640
Modulus of rupture	lb./sq. in.	11,270
Modulus of elasticity	lb./sq. in.	2,320,000
Work to limit of proportionality	inch lb./cu. in.	1·44
Work to maximum load	inch lb./cu. in.	9·5
Total work	inch lb./cu. in.	24·8
Toughness—		
Radial	inch lb./cu. in.	65·5
Tangential	inch lb./cu. in.	64·0
Average	inch lb./cu. in.	64·8
Compression Parallel to Grain—		
Crushing stress at limit of proportionality	lb./sq. in.	4,870
Maximum crushing strength	lb./sq. in.	5,850
Modulus of elasticity	lb./sq. in.	2,750,000
Compression Perpendicular to Grain—		
Fibre stress at limit of proportionality—		
Radial	lb./sq. in.	1,100
Tangential	lb./sq. in.	1,460
Average	lb./sq. in.	1,280
Hardness—		
Radial	lb.	1,510
Tangential	lb.	1,430
End	lb.	1,460
Shear—		
Radial	lb./sq. in.	1,190
Tangential	lb./sq. in.	1,460
Cleavage—		
Radial	lb./in.	380
Tangential	lb./in.	535

The tests show that the cross bending strength of the green clear wood of karri is 39 per cent. stronger than that of Canadian Douglas fir (6), 48 per cent. stronger than that of U. S. Douglas fir (5), and 36 per cent. stronger than that of English oak (3). Since the strength

of any piece of commercial timber is largely affected by the defects present, and since karri as a species is very free from injurious defects, it will be seen that, for structural purposes, much higher working stresses can be used than are required for the other species enumerated, resulting in a reduction in the size required for any particular purpose.

It was found that there was a tendency for the wood from near the butt of the tree to be less tough and weaker, but harder than that from higher up in the tree. However, the variation in mechanical properties with height in the tree is not very marked, nor is it consistent in different trees of the same species.

On the other hand, there is a marked variation in properties from pith to sap, the strongest and hardest wood occurring, in most cases, in the truewood adjacent to the sapwood. There is not much variation in the toughness of the truewood, but when brittle heart (4) is present, there is a sudden change in toughness from heart to truewood. On the other hand, there is no sudden change in the other mechanical properties at the transition from heart to truewood. The question of "heart" has been fully discussed elsewhere (4).

Statistical investigation showed that there is some correlation between strength and density, but it is not sufficiently close to enable the strength of any particular piece to be estimated with any degree of accuracy. However, in general, denser pieces will be stronger than the lighter pieces.

In the absence of tests on the dry material, it may be tentatively stated that the strongest and toughest material is obtained from the higher portions of the tree in the truewood adjacent to the sap, and pale-coloured wood appears to be superior to the darker material.

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A Note on the Evaluation of Australian Grown Pyrethrum Flowers.*

By A. B. Jaffray, B.Sc.†

1. Material Available.

The material available consisted of four samples of *Chrysanthemum cinerariaefolium* grown in Canberra under the supervision of Dr. A. McTaggart‡. They had been stored in calico bags in a laboratory cupboard for over twelve months before this series of estimations was done. The details of the sources of these samples are given in Table I. In order to reduce to a fine powder, they were dried at a moderate temperature (45°–50° C.), and then ground in a mortar to pass a No. 90 sieve. A small amount of fibrous material, which strongly resisted grinding beyond No. 60 powder, was mixed well with the finer; then the whole of the powder was exposed to the air overnight in order that it might again assume the air-dry condition, after which it was stored in stoppered bottles.

2. Method of Evaluating Pyrethrum Flowers.

The insecticidal properties of pyrethrum flowers is due to the presence of two esters, Pyrethrins I. and II. (Staudinger and Ruzicka). It has been determined by biological tests that Pyrethrin I. is much more toxic than Pyrethrin II., and, as both occur in approximately equal parts in the flowers, it is usually considered sufficient for an approximate evaluation of the flowers to determine the content of Pyrethrin I., especially as this is more conveniently estimated. With this idea Tattersfield, Hobson, and Gimingham (*J. Agr. Sci.* **19**: 266, 433) evolved what is known as the rapid acid method. The process consists essentially in extracting the Pyrethrins with low-boiling petrol ether, hydrolysing these by boiling with methyl alcoholic sodium hydroxide, and then acidifying and steam distilling. The acid resulting from the hydrolysis of the Pyrethrin I. passes over readily with the steam, while that from the Pyrethrin II. is non-volatile in steam and remains in the flask. The distillate is shaken out with petrol ether, which is then titrated with N/50 sodium hydroxide in a stoppered bottle with vigorous shaking.

3. Details of the Method as Used.

The method, in detail, was practically identical with that given in the British Pharmaceutical Codex 1934 for the estimation of pyrethrum flowers. Approximately 10 grams of the flowers in fine powder were extracted with petroleum ether (boiling range 40°—60° C.) in a continuous extractor of the British Pharmacopoeia 1932 type.

* Presented to Section O at the Melbourne meeting of the Australian and New Zealand Association for the Advancement of Science, January, 1935.

† Department of Pharmacy, University of Sydney.

‡ Of the Division of Plant Industry, C.S.I.R.

After six hours, the extract was boiled under a reflux for two hours with 5 ml. of normal methyl alcoholic sodium hydroxide, then acidified with normal sulphuric acid and steam distilled. The flask used throughout was a 250-ml. round bottom. When 150 ml. of aqueous distillate had collected below the petrol ether in the receiver, the volume of the petrol ether was adjusted to 50 ml., then the whole transferred to a separator, the receiver being washed with 20 ml. of water and 10 ml. of petrol ether. After adding 10 grams of sodium chloride, the separator was shaken for one minute. The aqueous layer, after separation, was further extracted with two lots of 20 ml. of petrol ether, then the mixed extracts washed with three lots of 10 ml. of water and run into a stoppered bottle, the separator being washed with 10 ml. of neutral alcohol and 20 ml. of water and these added to the bottle. After adding three drops of phenolphthalein solution, the contents of the bottle were titrated with N/50 sodium hydroxide till a distinct pink colour remained in the aqueous layer after shaking vigorously for one minute. A blank was also done on the petrol ether, starting from the beginning of the distillation. This required 0.40 ml. of N/50 sodium hydroxide.

4. Results.

The individual results obtained on the four samples estimated by this method are shown in Table I., all figures being calculated on the weight of the material dried at 100° C.

Table I.

Sample.	Strain.	Seed From.	Percentage of Pyrethrin I.				
			1.	2.	3.	4.	Average.
			%	%	%	%	%
2273	Swiss ..	England	0·410	0·370	0·404	0·387	0·393
2274	Japanese Commercial	England	0·359	0·367	0·367	..	0·364
2288	Japanese ..	Japan ..	0·507	0·546	0·553	0·525	0·534
2289	Japanese ..	U.S.A.	0·425	0·379	0·404	..	0·403

Care was taken to keep the conditions as constant as possible, and the results show a reasonable degree of accuracy.

It was thought that extraction may not have been complete in the six hours given, so, in order to test this, one of the samples (2288) was extracted for eight and three-quarter hours (see 1 and 2, Table I.) and for five and a half hours (3 and 4, Table I.). As may be seen, the results showed quite reasonable agreement in all four cases, the shorter period actually giving an insignificantly higher figure. It is on account of this agreement that all four results are grouped together and the average taken in Table I. Another experiment was also done on this sample, extracting first for three hours, then re-extracting the marc for a further three hours, and the Pyrethrin I. extracted in each

case estimated. The second extraction yielded only a trace of Pyrethrin I., although an appreciable amount of colouring matter was taken out. The results are shown separately in Table II.

TABLE II.

Sample.	Percentage of Pyrethrin I.		
	1st Extraction.	2nd Extraction.	Total.
2288	% 0·483	% 0·009	% 0·492
	0·514	0·012	0·526

5. Use of Acetone in the Extraction.

Previous experiments in this laboratory by Miss Nona Fraser, B.Sc., had shown that, unless the material was very finely powdered, incomplete extraction was obtained with petrol ether. It was, therefore, decided to try acetone as the extracting medium. The drug was extracted in a similar way to that already described, the acetone removed from the extract by distillation, and finally with a current of hot air, then 50 ml. of petrol ether and 5 ml. of normal ethyl alcoholic sodium hydroxide added, and the estimation carried to completion in the usual way. There was not sufficient of sample No. 2289 available to allow of its estimation by this method. The individual results obtained are shown in Table III.

TABLE III.

Sample.	Percentage of Pyrethrin I.					
	1.	2.	3.	4.	Acetone Extr. Averages.	Petrol Ether Extr. Averages.
	%	%	%	%	%	%
2273 ..	0·362	0.324	0·374	0·358	0·355	0·393
2274 ..	0·367	0·383	..	..	0·375	0·364
2288 ..	0·463	0·506	0·421	0·453	0·461	0·534

For convenience, the average figures obtained by both methods are set out side by side in Table III. The concordance appears fairly good, except in the case of No. 2288, where the results with acetone are appreciably lower, and no suggestion can be made to account for this.

6. Acknowledgments.

These analyses were undertaken at the request of Dr. B. T. Dickson, Chief of the Division of Plant Industry. Acknowledgment is due to Mr. H. Finnemore, B.Sc. (Lond.), F.I.C., for his interest and suggestions in the work.

The Apple-Thrips (*Thrips imaginis* Bagnall).

The following article is contributed by Dr. J. Davidson, of the Waite Agricultural Research Institute, University of Adelaide, who is in charge of the investigations on thrips, in which the Institute, certain of the State Departments of Agriculture, the Thrips Investigation League, and the Council are co-operating. The article summarizes the essential information relating to the control of the apple-thrips; it is based on results which have been obtained during the progress of these investigations.—Ed.

1. Introduction.

An investigation of the apple-thrips problem was commenced in 1932, as a result of the widespread losses caused by the thrips plague of 1931. Details of the organization of the investigation have been given in an earlier number of this Journal (**6**: 216, 1933). Articles dealing with various aspects of the work have also been published from time to time.

Work on actual control measures has been centred on insecticides which might be used to protect apple blossom, berry fruits, and other flowers during the critical periods of their infestations by thrips. Unfortunately, during the spring of 1933 and 1934, the numbers of thrips were too small to allow of adequate field trials being made. By means of laboratory and restricted field tests, certain insecticides have been selected for extended field trials; it is hoped that these may be carried out next spring.

The following information may be helpful to growers should thrips occur in economic numbers during 1935. The insecticides which are given below may be used, but it must be clearly understood that a definite opinion regarding their efficiency, under field conditions, cannot be expressed until results from adequate field trials have been obtained.

2. The Relation of Weather to the Numbers of the Apple Thrips in Spring.

The occurrence of spring infestations of the apple-thrips is associated with a sequence of favorable periods of weather. Records from Victoria, South Australia, and Western Australia show that the numbers are small during the dry summer months; they increase in autumn, giving an "autumn rise" which may develop any time during May to July. The extent of the autumn rise depends upon the weather; a warm, wet autumn with early rains favours increase in numbers.

During the winter months, relatively few active thrips are seen, owing to low temperatures. The species overwinters mainly as pupae in the soil, or as dormant adults. With warmer days in early spring, the numbers of active thrips increase, and produce the "first spring rise." This rise is due to the development of adults from pupae, and to renewed activity of dormant adults; it may develop in early spring or late, according to the prevailing weather, particularly temperature. The numbers which develop depend upon the extent of the previous autumn rise, survival during the winter, and the prevailing spring weather.

With the development of a further generation of the insects (offspring of first spring rise), a larger increase in numbers occurs later,

which is referred to as the "second spring rise." The date of its appearance and extent depends upon the date and extent of the first spring rise, and the favorableness of the weather, particularly temperature. In years when conditions favour the development of large numbers of thrips as a second spring rise in October, a heavy infestation of apple blossom may be expected; it will be particularly serious during short spells of hot, dry weather which favour the movements of thrips. If the weather continues favorable for thrips into early summer, infestation of bush and berry fruits and garden flowers may be expected. Thrips may be troublesome on these summer crops in some years, although the early spring numbers are small.

3. Thrips Prospect for the Spring of 1935.

The important weather features which favour the occurrence of thrips in economic numbers in spring are early autumn rains and a wet autumn, followed by an early and sustained warm spring.

The distribution of autumn rainfall for Adelaide in 1935 resembles that of 1931. The autumn rise of thrips at the Waite Institute appeared during 28th May to 20th June. The numbers were not large, the highest daily count from twenty roses during this period being 544; but thrips were more generally distributed than is the case in a dry autumn.

In southern Victoria, the summer of 1934-35 was cool and wet. Thrips numbers were well maintained until the middle of February, 1935. They decreased during the dry period extending into early April. From 8th April onwards, rainfall was adequate to maintain suitable soil moisture, but falling autumn temperatures were unfavorable for increase in the numbers of thrips. There was no appreciable autumn rise in the Melbourne area, but thrips were more generally distributed than is the case in a dry autumn.

No data are available for the autumn rise of the apple-thrips in Western Australia. In the Mount Barker district, rainfall and temperature during April and May were favorable for its increase in numbers. In the Bridgetown district, adequate rains fell from early April onwards; the mean temperatures for April and May were above the average. These conditions would favour the autumn rise in numbers with a useful winter "carry-over."

The autumn weather therefore has been favorable for increase in the numbers of thrips, but it is not possible at this stage to say what the position will be in spring. Plants flowering about the orchards in early spring should be examined to ascertain the extent to which the apple-thrips is present; the numbers will indicate the significance of the "first spring rise." Given a warm early spring with an appreciable increase in the numbers of thrips in early spring, the species may become troublesome. If the warm weather is maintained, with spells of hot days in early October, the insects may become numerous enough to cause damage to apple blossom.

4. Suggestions for Control Measures.

When a large population of the apple-thrips develops in an area, the insects tend to move actively, particularly on hot, dry days, and to infest flowers and blossom. With most varieties of apple, they can enter the buds at the base of the petals, before the buds open; they damage the stamens and pistil, and, if numerous, the blossom may not set fruit.

They also feed on the exposed portion of the petals, causing them to turn brown. When the buds open, the insects continue to infest the blossom.

During a heavy infestation, it is impracticable to aim only at killing the thrips infesting the blossom, since the insects are abundant over a wide area. The aim should be to drive the thrips out of the blossoms, and protect the latter during the critical periods of the invasion by the application of suitable dusts or sprays. It is important to anticipate movements of the thrips, and suitably time the application of the insecticide. It is best if the protective cover can be applied when an invasion is imminent, which will normally occur during hot days.

(*a*) *Treatment of unopened buds.*

Spraying or dusting as for open blossoms (*b*) may be used. A finely-ground substance like kaolin, applied as a wet spray, to which a spreader has been added, may form a temporary mechanical barrier over the openings into the buds, and prevent the entrance of thrips. The spray is cheap and harmless, and may be applied in heavy doses. We have had insufficient field experience with this method to enable us to make any recommendation at present. The spray is of no use applied to open blossom.

(*b*) *Treatment of open buds.*

The aim should be to apply an insecticide which will drive thrips out of the open blossom, and keep them out during critical hot days. Dusts are convenient for this purpose, and the formula given below has given promising results with small tests:—

	Per cent.
Kaolin or talc	80 or 70
Derris (finely-ground)	15 or 20
Pyrethrum (finely-ground) ..	5 or 10

Derris and pyrethrum repel thrips; they gradually lose their toxic properties on exposure to air and sunlight. In orchard practice, it is not expected that the dust will be effective for more than two days after application to the trees. Further applications will be required as necessary. Dusts having the higher concentrations of derris and pyrethrum will be more efficient, but more costly. The formula is based on ground derris root, of which about 90 per cent. passes through a 200-mesh sieve, and containing 3.5 per cent. rotenone; the pyrethrum used contained 0.2 per cent. pyrethrins. A hand rotary or knapsack duster can be used for small areas; a larger machine will be desirable for extensive areas; a suitable allowance of dust is ½ lb. per tree. Where derris cannot be obtained, a pyrethrum dust may be used, but its efficiency will be considerably less than a dust containing both derris and pyrethrum.

We have had little success up to the present with experiments with sprays. It is recommended that dusts should be used wherever possible.

For growers who desire to use a spray, the following formula is suggested:—

Finely-crushed derris root	2 lb.
Soap	5 lb.
Water	100 galls.

This spray can be made up by the grower; it must be prepared fresh, immediately before use, since it deteriorates in efficiency on standing.

Oil emulsions containing derris and pyrethrum appear to be more promising than aqueous sprays, but the work in progress on these emulsions is still in the experimental stage.

The dust formula given above may be used for bush and berry crops and for garden flowers.

NOTES.

In connexion with the May meeting of the Standing Committee on Agriculture, a number of summaries of information dealing with matters of concern to the Council were prepared. As it is thought that some of them are of general interest, a selection is published (in slightly condensed form in one or two cases) as the "notes" that appear on pages 237 to 245.—[Ed.]

Investigations in Connexion with the Apple Industry.

C.S.I.R. is carrying out investigations into various problems affecting the apple industry, as follows:—

1. Investigations into the various types of disorders which affect different varieties of apples in storage are being conducted in Tasmania by Mr. W. M. Carne, of the Division of Plant Industry, working in co-operation with the Tasmanian Department of Agriculture and the University of Tasmania. These disorders, which are of a very complex nature, are being determined and classified. Definite information is being obtained regarding the conditions under which they are developed, and methods of control are being studied. The investigations are of importance, not only with respect to the apple export industry but also in connexion with the elimination of unprofitable or undesirable varieties of apples.

Studies of the effects of seasonal climate on the quality and storage capacity of apples are being conducted in conjunction with those on maturity, size of crop, &c., and, whilst the effects are obviously difficult to determine, in some cases definite correlations have been found. For example, severe water-core accompanies heat waves in the fruit-growing season, and crinkle follows if the hot conditions are severe and prolonged. If the heat wave occurs during, or just prior to, picking, so that when picked the fruit has water-core, it will develop breakdown in storage.

2. Investigations are also being conducted into the problem of alternate light and heavy bearing of apple trees. Except in a few instances neither manurial, pruning, nor fruit-thinning practices have given any satisfactory results with respect to this problem, either in Australia or elsewhere. In the hope that the investigation into the process of fruit bud formation might indicate a point of attack on this problem, the Council's Division of Plant Industry has, in co-operation with the Victorian and South Australian Departments of Agriculture, made studies of the process of fruit bud formation, and the relation of this process to the growth of the tree in apple varieties of both biennial and annual cropping habits. The information thus obtained, whilst increasing our knowledge of the mechanism of the process, emphasizes the difficulty of controlling the biennial cropping habit by means of cultural operations performed subsequent to blossom time.

Two lines of further investigations are indicated:—

(i) The development of a commercial method whereby the heavy blossom of the "on" year may be reduced to an amount sufficient to set a moderate crop.

(ii) The discovery of strains of varieties, in which the feature of alternation is not so pronounced (*vide* citrus). A search of established orchards may result in the discovery of strains possessing the quality of even cropping.

3. In co-operation with the Queensland Committee of Direction of Fruit Marketing and the Queensland Department of Agriculture and Stock, an investigation has recently been commenced at Stanthorpe into the question of the type of stock most suited to the requirements of that district. Certain East Malling stocks are being used and compared with other stocks, such as Northern Spy and seedling stocks, but it will be some years before results are likely to be available.

4. The different types of wastage occurring in Jonathan apples in cold storage and the conditions giving rise to them are being studied intensively in co-operation with the Victorian Department of Agriculture at the Government Cool Stores, Melbourne. The object of the investigations is to determine the effect of maturity, locality, and tree individuality on the keeping qualities of the apple. Satisfactory progress has been made in the work, and it is anticipated that before long it will be possible, as a result of the investigations, to make definite recommendations regarding Jonathan apples for export, particularly in regard to the degree of maturity at picking.

5. The Council's Division of Forest Products, in co-operation with the Standards Association of Australia, has conducted an extensive series of experiments into the most suitable type of case for apple exports. The evidence which was obtained showed that different types of cases were used in the apple export trade, and that serious inconvenience in production, packing, and stowing, and adverse comment in marketing resulted. The first step was, therefore, the elimination of a number of undesirable types of cases, following on action which had already been taken in this direction by the Apple and Pear Export Council.

6. Under the Commerce Regulations, two types of cases are now permitted, viz., the Canadian and the dump. The Regulations are, however, of a broad nature regarding variations in capacity, and, in addition, make no provision for the sizes of the individual parts of the case. Commercial cases are accordingly at present far from being standardized.

The results of the experiment showed that a case of the dump shape, enlarged from the statutory $8\frac{2}{3}$-in. width to 9 inches in order to accommodate the minimum weight of fruit required by overseas buyers, gave the best protection to its contents. An experimental shipment of 540 cases was made by the Council in 1934, but the results were inconclusive. Apparently, any difference in respect to liability to bruising which might have existed between the two types of case was hidden by undetermined causes of bruising more important than the type of case.

C.S.I.R. and the special committee on fruit cases appointed by the Standards Association of Australia have undertaken sufficiently detailed tests and export trials to show that the question of standardization of the apple case is influenced at present by factors other than the protective value of the cases. It appears that the industry should make the next

decision as to how largely bruising affects the sales value of apple consignments. It should then take the necessary steps to choose a standard which will give the requisite degree of protection and at the same time fulfil the majority of the marketing requirements.

Investigations into Citrus Problems.

(1) *Preservation and Transport of Oranges.*

1. For some years past, the Council for Scientific and Industrial Research has been conducting investigations into problems connected with the preservation and transport of oranges. The investigations, which were under the control of a Citrus Preservation Committee, were of a restricted nature owing to the fact that only a small sum of money was available for the purpose. Nevertheless, a great deal of valuable information has been accumulated regarding maturity at time of picking in relation to storage life, and the handling and conditions of storage of oranges, particularly Victorian oranges.

2. Consequent on the approval given by the Commonwealth Government for a grant of £2,000 per annum for five years for citrus preservation work, steps were taken by C.S.I.R., in consultation with the States concerned, to prepare a programme of work for extending the investigations of the Citrus Preservation Committee. The programme provides for investigations to be conducted on uniform lines at three centres, namely, Newcastle, Melbourne, and Griffith.

3. It has been agreed that all the work in connexion with respiration tests (which give a measure of the "rate of living" of the fruit) shall be done in Melbourne. The influence of variable factors in the orchard on keeping qualities will be studied principally at the Council's Citricultural Research Station, Griffith, where special facilities are available for that purpose.

The importance of including fruit from both the Murray Valley and Adelaide Plains districts of South Australia has not been overlooked, but, as cold storage facilities for experimental work are not available in Adelaide, it has been arranged that the fruit from these districts shall be brought to Melbourne for storage.

In order that results from experiments in the various centres shall be directly comparable, uniform methods have been agreed on with regard to the amount of fruit to be used for the experiments, dates of picking, temperature of storage, methods of examination and so on.

4. The programme includes a comprehensive scheme of investigation into the preservation, &c., of Navel oranges. Investigations on the influence of orchard factors on keeping qualities will include such matters as (*a*) the influence of stock on keeping qualities, (*b*) the influence of strain on keeping qualities, (*c*) environmental factors such as extent of irrigation, effect of different methods of cultivation, &c., and (*d*) maturity of fruit at time of picking.

Experiments will also comprise investigation into types of sweating, processing, and wrapping.

5. As regards common oranges, experiments will be carried out with three export varieties, namely, Joppa, Silletta, and Parramatta, which

will be picked at each of three different stages of maturity, and will be stored at uniform temperatures.

6. Important aspects of the agreement which has been reached are (*a*) the consolidation which has been effected in the various phases of the work in the different centres, and (*b*) the close co-operation which has been established between C.S.I.R. and the Departments of Agriculture in New South Wales, Victoria, and South Australia. The responsibilities of the Council, on the one hand, and the Departments of Agriculture in the three States on the other, have been clearly set out, and work is now in progress.

It has been decided that the investigation shall be under the general direction of an Advisory Technical Committee, consisting of representatives of C.S.I.R. and the three Departments of Agriculture, and, moreover, that a General Co-ordinating Committee (which will meet only at infrequent intervals) shall be appointed, mainly for the purpose of obtaining the help of growers and others concerned with the citrus industry, and to facilitate transport and other arrangements. This general committee will include representatives not only of C.S.I.R. and of the three State Departments of Agriculture, but also of the Federal Citrus Council, the Australian Citrus Export Association, the Overseas' Shipping Representatives Association, and the Australian railways.

[NOTE.—The above scheme of work has now been approved by the Australian Council of Agriculture.—ED.]

(ii) *Citrus Investigations in Lower Murray Valley.*

Arrangements have been made for the appointment of a committee, to be known as the Citrus Advisory Committee for the Lower Murray, consisting of representatives of C.S.I.R., of the New South Wales, Victorian, and South Australian Departments of Agriculture, and of citrus growers in these three States. The main functions of the committee are to collate available information, consider avenues for research, and to secure the co-ordination on the present investigations through C.S.I.R. and the State Departments of Agriculture. Problems such as the control of red scale, fertilizer trials, and irrigation practices, are of special importance and particular attention is being given to them.

(iii) *Control of Fruit Fly, &c.*

As a result of a resolution passed at a meeting of the Commonwealth Citrus Investigation Committee held in Melbourne in September, 1934, a proposal was put forward to the Prime Minister by the Premier of New South Wales to send an officer abroad with a view to obtaining parasites of the fruit fly and the white wax and white louse scales. The Premier of New South Wales pointed out that the officers of the Entomological Branch of the Department of Agriculture were of the opinion that in all probability fruit fly could be controlled by biological methods. Three species of parasites have been introduced from Hawaii, but so far they have not been recovered in the orchards. There are other parasites in India and West Africa. Although repeated attempts had been made to obtain these parasites from different countries, this had not so far been possible, and it was considered desirable that a trained entomologist should visit Ceylon, India, and West Africa in order to collect parasites and forward them to Australia.

The Fruitgrowers' Federation of New South Wales strongly supported the proposal, and has made a sum of £250 available towards the expenses. The Commonwealth Bank is also making a contribution from the Rural Credits Development Fund. The New South Wales Department of Agriculture will pay the salary of the officer, and the Premier of New South Wales asked the Prime Minister if the Commonwealth Government would contribute a sum of £450.

The proposal made by the Premier of New South Wales has been supported by the Australian Council of Agriculture, and the Commonwealth Government has agreed to contribute the sum asked for. The officer has already left Australia.

Banana Investigations.

C.S.I.R. is carrying out investigations into several problems affecting the banana industry. They are as follows:—

(I) *Investigations into the Handling, Transport, Ripening, and Storage Diseases of Bananas.*

In 1929, C.S.I.R. commenced investigations on the ripening of cased bananas, with a view to determining the precise conditions required for development, by artificial means, of the best colour, flavour, and texture. The investigations have been carried out successfully, and the conditions of temperature, humidity, concentration of unburnt coal gas, and ventilation have been defined both for winter and summer grown fruit, and definite information has been obtained regarding the precautions to be adopted on the plantations and during transport, in order that fruit may arrive in a firm condition at the ripening centres. The investigations disclosed the need for the provision of ripening rooms adequately equipped with refrigeration, automatically controlled heaters, and forced air circulation. As a result, several sets of ripening chambers have now been erected in Sydney, Melbourne, and Brisbane, and the experience of commercial ripening in such establishments has amply confirmed the results of the laboratory experiments.

Extensive investigations into the conditions obtaining during transport have been carried out by C.S.I.R., in co-operation with officers of the New South Wales Government Railways. The results have been published in C.S.I.R. Bulletins, Nos. 64 and 91.

Investigations of parasitic diseases of transport and ripening of bananas, such as "squirter" and "black-end", have also been conducted. The causal organisms responsible for these two diseases have been identified. No great progress, however, has yet been made in the discovery of preventive measures, and further investigations are in progress.

Investigations are also in progress, in co-operation with the New South Wales Department of Agriculture, into the condition known as "rubbery" or "leathery" bananas.

(ii) *Investigations into Banana Cases.*

These investigations were conducted by the Council's Division of Forest Products. The factors studied were: (*a*) the species of timber, (*b*) the thickness of the timber, (*c*) the nailing schedule, (*d*) wiring,

and (*c*) the extent of the bulge. The results showed that the use of badly milled shooks, and lack of care in construction, are mainly responsible for inferior cases. As regards bulge, it was found that in practice, failure is usually due to a combination of high bulges and thin tops. The results of these investigations have been published in the Council's quarterly Journal.

(iii) *Banana By-products.*

As a result of a conference held at South Grafton in January, 1935, C.S.I.R. was asked to obtain information regarding the manufacture of banana by-products, such as banana flour, banana dates, banana coffee, and banana sweetmeats. A search of the literature showed that very little information was available, though some particulars were obtained regarding the manufacture of banana flour. References were also obtained as to the names of companies manufacturing banana by-products in England and the United States of America, and letters have been sent to the Official Secretaries, at Australia House, London, and New York, asking them to obtain information regarding processes of manufacture, together with samples, particulars, and prices, &c.

(iv) *Allocation of Commonwealth Grant of* £1,500 *for Banana Investigations in* 1935.

A sum of £1,500 has been made available by the Commonwealth Government for investigations into banana problems, and has been allocated as follows:—

Banana thrips investigations (Queensland Department of Agriculture)	£476
Diseases of transport and maturation (C.S.I.R.) ..	376
The investigation of "rubbery" bananas (C.S.I.R.) ..	75
Beetle borer investigations (New South Wales Department of Agriculture)	150
Contingencies	423
Total	£1,500

The Grasshopper Pest.

1. At a meeting of the Standing Committee held at Canberra in December, 1934, consideration was given to the question of carrying out certain fundamental investigations into the grasshopper pest. It was pointed out that grasshopper plagues have occurred over agricultural areas in several of the States at infrequent intervals for many years past. With increased development of agricultural lands, these invasions have become a very serious menace in recent years. When a widespread plague occurs, heavy losses in pasture and cereal crops are experienced, and considerable expenditure on control measures is necessary.

2. The Standing Committee passed a resolution requesting C.S.I.R. to undertake investigations into the habits and ecology of the plague grasshopper, particularly with a view to obtaining definite information regarding the breeding grounds of the insects, and the conditions which lead to their development in plague numbers, and to devising, if possible, methods of prevention or destruction in localities where they breed.

3. The Standing Committee also decided to recommend that a sum of £1,000 per annum should be made available for the purposes of the investigations, in addition to a capital outlay of about £500. It is impossible to state definitely the period for which the work would have to be continued, but initially arrangements should be made for a period of five years.

4. The matter again came up for consideration by the Standing Committee on Agriculture at its last meeting, when the resolution previously passed was confirmed. The Standing Committee urged the desirability of the investigations being conducted by C.S.I.R. in close co-operation with State entomologists, who would assist in making surveys of the distribution, species, life-histories, &c., of the insects.

5. Mr. A. L. Tonnoir, Senior Entomologist, on the staff of C.S.I.R., has recently left on a visit abroad and will obtain most recent information regarding steps for combating the grasshopper plague in Egypt, Algeria, and other countries. In 1931, an International Commission was established to co-ordinate research on the grasshopper pest in various countries of the Old World. The headquarters of this Commission are in London, and it is anticipated that Mr. Tonnoir will be able to obtain a great deal of valuable information from that source.

[NOTE.—The Standing Committee on Agriculture decided that its recommendations on the matter should be brought before the Australian Council of Agriculture. This was done, and the Council of Agriculture decided to support the proposals, and to recommend that the necessary funds be made available.—ED.]

Tobacco Investigations.

The investigational work undertaken by C.S.I.R. covers the following four phases:—(i) disease studies, (ii) chemical investigations, (iii) curing experiments, (iv) processing investigations and smoking tests.

(i) *Disease Studies.*

(A) Of the disease studies, those concerning downy mildew (blue mould) still occupy the most important place, as this disease has continued to take heavy toll of the crop during the last two years, in marked contrast with the relatively disease-free crop of 1932.

Experiments have been concentrated mainly on seed-bed control because, although, in late summer and autumn, field mildew attracts much attention, especially in late planted crops, it is the seedling supply which determines initially the potential crop. These experiments are briefly described in the succeeding five paragraphs.

(i) Experiments in the use of copper emulsion, colloidal copper, and Bordeaux mixture sprays were carried on at Wangaratta, Victoria, Deniliquin, and Ashford, New South Wales. The sprays did not prevent infection, but they tended to check the spread of the disease. Bordeaux mixture was not as effective as the sprays recommended by the Queensland Department of Agriculture.

(ii) At Ashford, in co-operation with the New South Wales Department of Agriculture, and at Wangaratta, the "Bathurst" type of seed-bed was used to ascertain whether

healthy seedlings could be raised without the use of sprays, but during the past season they were not successful in preventing or controlling downy mildew.

(iii) During late spring and summer, experiments on a small scale were designed in Canberra to test the effects on the disease of the use of substances which would vaporize readily, such as petrol, toluol, benzol, &c. These were distinctly promising, and accordingly, despite the fact that it was autumn, a larger scale trial was set up in Canberra and at Eurobin, Victoria. In the former place, fourteen cold frames were used, and at Eurobin, by courtesy of Panlook Brothers, seventeen seed-beds of the Bathurst type were made available. The experiments are still in progress, and are available for inspection. In both places, toluol and benzol were used, and at Canberra petrol additionally, with adequate checks. Vapours were used only when beds were closed, i.e., at night, and when days were wet, and during fine days they were wide open. All beds were inoculated heavily with viable conidia two or three times, in addition to natural exposure to infection by day. The check beds are wiped out; the benzol-treated beds are free from disease, and the toluol-treated beds show a little disease.

The trials will be continued during the coming spring. At present it can be said that the experiments have given extremely satisfactory results, especially with benzol, but much more work remains to be done.

(iv) Whatever control may be reached by the application of substances to plants, it is costly as compared with the use of resistant or immune varieties. No varieties of commercial tobacco are resistant, but some are not so highly susceptible as others. The testing and crossing of some types is in progress, but it is felt that the chances of obtaining a truly resistant type, particularly from commercial varieties, are rather slender. One avenue should be explored, however, and that is the search in the native home of tobacco, viz., South and Central America, for types which, while not commercially valuable, might be resistant to the disease, and, therefore, valuable in hybridizing with some of our commercial lines to build up resistant strains.

(v) Data are being accumulated with respect to the incidence of epidemic outbreaks and climate, host relationships, overwintering, &c. This year again, the disease is occurring in the field wherever plants are still standing. *Nicotiana glauca,* a wild host, was found on 16th May to be heavily infected at Cobram, Victoria, which used to be a centre for the growing of seedlings.

(B) The other disease which has been under investigation is that which is known as frogeye, and which may be serious in Central and North Queensland in wet seasons. In a preliminary publication, it was pointed out that the fungus causing the disease may be found associated with the seed, leaf scrap, the soil, and overwintering plants, and that

it could be controlled by using clean seed in clean seed-bed soil, and by spraying the seedlings. Experiments conducted at Mareeba showed that sprays recommended by the Queensland Department of Agriculture for downy mildew control are effective in seed-bed control of leafspot.

(ii) *Chemical Investigations.*

These are in progress at the University of Sydney, and are designed to discover the causes of low quality in certain leaf and ultimately to devise methods whereby improvement in quality may be effected. Having been started not quite a year ago, it follows that preliminary work only has been possible, but tests show that leaf of low quality tends to be low in carbohydrate, high in nitrogen, and to give smoke which is highly alkaline to litmus.

Chemical analyses of samples of natural or processed leaf are correlated with smoking tests. The following table illustrates relative values for certain samples:—

Sample Smoking Quality.	Good American.	Australia Good.	Australia Good.	Australia Good.	Australia Poor.	Australia Poor.
Alkalinity ..	..	1·0	1·4	2·0	10·6	11·3
Nitrogen content ..	1·77	1·52	1·32	1·69	3·42	4·00

Studies were begun on the changes in nitrogen constituents in the plant during growth, through the processes of topping, suckering, and early ripening, and finally during curing.

(iii) *Curing Investigations.*

In order to determine whether the longer curing processes adopted in other countries for heavier types of leaf were applicable to heavier leaf in Australia, trials in which the curing was more prolonged, especially at lower initial temperatures than is usual, have been in progress at Wangaratta for three years. Smoking tests on this year's trials have not been made, but results from the previous seasons show that, with mature fine-textured leaf, there is no advantage in prolonging the curing process at present in use, whereas, with heavy and/or immature leaf, both colour and quality were improved by a 10-14 days curing period.

(iv) *Processing Experiments and Smoking Tests.*

Smoking tests are in progress with cured leaf before conditioning and storage for maturation, after maturation but before processing and manufacture, and after manufacture. They are correlated with chemical analyses, curing methods, soil type, climate, &c., and cover the range of samples which the various States have agreed to provide.

Processing experiments were commenced in Sydney about a year ago, and some 1,000 lb. of leaf has been conditioned and stored for varying periods of maturation. Preliminary manufacturing tests with 1932 crop leaf, involving the use of sugar, honey, liquorice, and such acids as acetic, malic, citric, &c., have been made, and these tend to indicate that smoking quality is improved by such treatments. The work is obviously still in the initial stages.

Black Disease of Sheep: French Investigations.

Since the publication of the Council's Bulletin No. 46, in which Dr. A. W. Turner detailed his investigations and those of others conducted in Australia, it is interesting to note that black disease of sheep is now definitely recognized to exist not only in Australia and Tasmania, but in New Zealand, France, Germany, Roumania, and Chile. Although it has not yet been recognized to exist in Great Britain, the existence of the bacillus has been determined on four occasions in the bodies of dead sheep in that country.

In a recent issue of the *Comptes Rendus des Séances de la Société de Biologie,* there is an interesting article by Cernaianu and Mihailescu on "The Infectious Necrotic Hepatitis due to *B. oedematiens* in Bessarabia, and the Active Immunization by the aid of Anacultures."

The authors recognize the great importance of what they term "the remarkable work of Turner, and of Turner and Davesne, who have elucidated the problem in showing that the infection called "black disease" in Australia, and characterized by necrotic hepatitis is caused by the *B. oedematiens* of Weinberg and Séguin."

They record that since 1932 they have studied a very deadly infection observed in sheep of the Karakul race in Bessarabia, and that they have been able to identify it with the disease known in Australia as "black disease." The mortality is very great, although it varies in different flocks. On one property, 35 to 40 animals out of a total of 200 died, in another 15 cases per week occurred in a flock of 600 sheep; while in others the incidence was greater or less. They found the progress of the disease of such a rapidity that the symptoms were rarely noticed. In the cases studied by them, they always found a massive infestation of the liver by *Dicrocoelium lanceatum,* a genus of fluke quite different from that known in Australia (*Fasciola hepatica*).

Using the method of vaccination devised by Turner, they were able to actively immunize laboratory animals and sheep. They have vaccinated infected flocks where the mortality was very great, and found that after three to four days it was completely arrested. No case of "black disease," with the exception of one only in 1933 (six months after vaccination), in a ram which died during transport, has been observed.

The authors conclude by stating that the sheep-owners greatly appreciate the benefits of this vaccination, of which they are "demanding the extension."—J. A. G.

The Division of Animal Health—Appointment of Dr. L. B. Bull as Chief.

Early in 1934, Dr. L. B. Bull, who at that time was the Director of the Government Laboratory of Bacteriology and Pathology of the Adelaide Hospital, was appointed to the Council's staff as Deputy-Chief of the Division of Animal Health, and left on a visit abroad to make himself thoroughly acquainted with the work going on in the principal veterinary institutions of Great Britain, Europe, the United States of America, and South Africa, and also to make personal contact with the principal veterinary investigators of those countries.

Dr. Bull reached Fremantle on his return to Australia, via South Africa, on the 16th June, 1935. After spending a few days inquiring into various animal problems in Western Australia, he came on to Melbourne, where his future headquarters will be.

As from 1st July, 1935, he took over the control of the two Divisions of Animal Health and Animal Nutrition: thus, in future, Dr. Bull will be responsible for the nutritional as well as the health side of the Council's animal investigations.

The Council feels particularly gratified that it has succeeded in obtaining the services of Dr. Bull at a time when the former Chief of the Animal Health Division, Dr. J. A. Gilruth (under whom, incidentally, Dr. Bull was a student many years ago at the University of Melbourne), is approaching the retiring age. It is grateful, too, for the excellent services Dr. Gilruth has given the Division at a period when the organization and co-ordination of its scattered activities were the main duties of a leader.

In order to facilitate the change-over, and particularly in view of the heavy task Dr. Bull has in front of him in organizing the mastitis work now commenced in Victoria and in co-ordinating the activities of the nutritional and health sides of his Division, it has been arranged that Dr. Gilruth will remain with the Division for some time, taking the title of Consultant.

Bovine Mastitis—A Survey of the Literature.

Some time ago, when the Australian Dairy Cattle Research Association was formed for the purpose of encouraging the investigation in Australia of two important troubles of the dairying industry, namely, contagious abortion and mastitis, arrangements were made for Mr. E. Munch-Petersen, M.Sc., Ph.B., of the Council's F. D. McMaster Animal Health Laboratory, to make a survey of the literature as a first step to the possible initiation of experimental work. That survey has now been completed, and the way is clear for an enlightened attack on what is a most difficult problem.

In the course of his work, Mr. Petersen consulted almost 2,000 publications, and covered all the literature available up to the end of the year 1933. One result has been to show how divergent are the conclusions so far arrived at concerning the nature, etiology, prophylaxis, and curative treatment, and how much remains to be done before the complete elucidation of the problem can be effected.

In his preface, the author states that the survey is the expression of an endeavour to abstract and correlate work which has been carried out concerning the various phases of the problem of mastitis in dairy cattle, particularly what is known as streptococcal mastitis, and that the intention is that it will serve to direct attention to the knowledge available and also to records which can be advantageously studied in greater detail by investigators of some particular aspect of the subject.

A limited number of copies of the survey (each consisting of 259 foolscap pages plus another 138 pages of bibliography) have been mimeographed and distributed to organizations, veterinarians, and investigators to whom the survey is likely to be of value. Copies cannot be made generally available, and in any case they would only be of use to scientific investigators interested in the problem.

Recent Publications of the Council.

Since the last issue of this Journal, the following publications of the Council have been issued:—

Bulletin No. 91.—"Further Investigations into the Transport of Bananas in Australia," by E. W. Hicks, B.A., B.Sc., and N. E. Holmes, B.E.E.

Investigations discussed in this publication are an amplification of several aspects of the co-operative work described in the Council's Bulletin No. 64. Particular attention was paid to the methods of handling on the plantations and to the condition of the fruit on loading into the trains. Conditions of transport were watched on the Queensland, New South Wales, and Victorian railways. Particular attention was paid during the summer to conditions of transport in several types of New South Wales railway trucks. Surveys of the variations of fruit temperatures, both in time and space, and of the directions and rates of air flow through the loads, were carried out on various types of stacks. Methods for securing the virtual elimination of mixed ripe fruit are recommended for adoption by growers.

Pamphlet No. 55.—"The Selection, Preservation, Distribution, and Identification of Australian Pole Timbers" (Division of Forest Products—Technical Paper No. 17), by J. E. Cummins, M.Sc., and H. E. Dadswell, M.Sc.

The results of an extensive survey of present practices of users of poles in Australia carried out with the aid of a large number of pole-using organizations are given. Data concerning the number, size, class, average cost, renewals, and annual extensions of poles are included. The various factors, such as termites and decay, affecting the life of poles and those features likely to occur in the pole and which may affect its service life are discussed, and a description of the most important methods of pole preservation and their probable relative economy outlined. In order to assist pole-users, a general description of the timbers used for poles and their distribution and keys for their identification are included.

Forthcoming Publications of the Council.

At the present time, the following future publications of the Council are in the press:—

Bulletin No. 92.—" The Apple-growing Soils of Tasmania. Part 1, A General Investigation of the Soils, by C. G. Stephens, M.Sc.; Part 2, A Soil Survey of Part of the Huonville District," by J. K. Taylor, B.A., M.Sc., and C. G. Stephens, M.Sc.

Bulletin No. ?.—" A Complement-fixation Reaction for the Diagnosis of Contagious Bovine Pleuro-pneumonia: Its Use in Experimental Investigations and in the Control of the Disease," by A. D. Campbell, B.V.Sc., and A. W. Turner D.Sc., D.V.Sc.

Bulletin No. ?.—" Radio Research Board: Report No. 9."

Pamphlet No. 56.—" The Occurrence of Bovine Babesiellosis in Northern Australia," by John Legg, B.Sc., D.V.Sc., M.R.C.V.S.

Pamphlet No. 57.—" Tests of the Efficacy of the Oxy-acetylene Scouring and Charring Process for Sterilizing Partly Decayed Poles" (Division of Forest Products—Technical Paper No. 18), by J. E. Cummins, M.Sc.

Pamphlet No. ?.—" Certain Aspects of Investigation on Black-end Disease of Bananas in Australia" by Shirley Hoette, M.Ss.

H. J. GREEN, Government Printer, Melbourne.